A COLLECTION OF ESSAYS
FOR FACTUM FOUNDATION

We must expect great innovations to transform the entire technique of the arts, thereby affecting artistic invention itself and perhaps even bringing about an amazing change in our very notion of art.

Paul Valéry, 'The Conquest of Ubiquity', *Aesthetics*, 1928

Digital technologies are profoundly changing how we relate to art, from the ways in which we access and display objects to how we safeguard, restore, archive and even possess them.

The Aura in the Age of Digital Materiality explores themes emerging from the unprecedented potential of the meeting between digital technology and cultural heritage at a time when we are being forced to fundamentally rethink what we value, how and why. It brings together recent projects by Factum and a wonderfully diverse collection of essays, many written especially for this book, by collaborators and friends. Their widely different backgrounds and disciplines only illustrate the importance of this subject and the huge range of its relevance. Contributors include Hartwig Fischer, Director of the British Museum; Mari Lending, the author of *Plaster Monuments: Architecture and the Power of Reproduction*; Nadja Aksamija, Professor of Italian Renaissance and Baroque art and architecture at Wesleyan University; Egyptologist Nicholas Reeves; Pulitzer Prize-winning author Richard Powers; Shirley Djukurnã Krenak, Indigenous activist from the Upper Xingu; philosophers Bruno Latour, Brian Cantwell Smith and Alva Noë; Simon Schaffer, Professor of the History and Philosophy of Science at the University of Cambridge; architect Charlotte Skene Catling; Jerry Brotton, specialist in cartography and the Renaissance; and Chiara Casarin, Director of the Musei Civici di Bassano del Grappa.

Our world is at a crossroads. Not only are people at risk, but our cultural heritage is under threat from lack of resources, natural disasters, climate change, terrorism, mass tourism and war. There has never been a more critical time to use technology for preservation. If these high-resolution methods had been used to record Aleppo before it was flattened, the site of Nimrud or the Bamyan Buddhas before they were blown up, or Notre Dame before it burned, these examples of human creativity would not have been so completely lost forever. When Dresden was bombed, only photographs and memories remained. In the 21st century, we have the technological means to do so much: we urgently need to act now to record and preserve our cultural heritage for future generations. This book is a thoughtful and provocative call to action.

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The project is part of the exhibition

LA RISCOPERTA DI UN CAPOLAVORO

12 March – 28 June 2020
Palazzo Fava, Palazzo delle Esposizioni, Bologna

A project of:

In collaboration with:

Under the patronage of:

Pontificio Consiglio della Cultura

Chiesa di Bologna

With the contribution of:

A collection of essays assembled by Factum Foundation to accompany the exhibition

The Materiality of the Aura: New Technologies for Preservation

Palazzo Fava, Bologna
12 March – 28 June 2020

'Factum Arte' can be translated from the Latin as 'made with skill'. Factum's practice lies in mediating and transforming material. Its approach has emerged from an ability to record and respond to the subtle visual information manifest in the physical world around us. Hundreds of decisions are embedded as material evidence in the process of making an object of any kind. Archaeologists are trained to read this evidence, as are forensic detectives at a crime scene. Patrick Blackett, an experimental physicist, wrote that his work was to 'cultivate an intimacy with the behaviour of the physical world' – this is an equally good description of Factum's aims.

Credits
This book has been assembled and edited by Adam Lowe, Elizabeth Mitchell, Nicolas Béliard, Giulia Fornaciari, Tess Tomassini, Blanca Nieto and Guendalina Damone.

All projects carried out by the Factum Foundation are collaborative and there are many people to thank. This is not the place to name everyone but some people have done a great deal to make all this work possible including: Charlotte Skene Catling, Otto Lowe, Tarek Waly, Simon Schaffer, Pasquale Gagliardi, Fondazione Giorgio Cini and everyone in ARCHiVe, Bruno Latour, Hartwig Fischer, Jerry Brotton, Roberto Terra, Cat Warsi, John Tchalenko, Manuela Mena, Peter Glidewell, The Griffith Institute, Emma Duncan, Lord Rothschild, Fabia Bromofsky, Ana Botín, Paloma Botín, Lady Helen Hamlyn, Ziyavudin and Olga Magomedov, Rachid Koraïchi, Andrew Edmunds, Colin Franklin, Ed Maggs, the Hereford Mappa Mundi Trust, Rosemary Firman, Philip Hewat-Jaboor, Helen Dorey, Peter Glidewell, Purdy Rubin, Fernando Caruncho, Susanne Bickel, Markus Leitner and everyone at the Swiss Embassy in Cairo, Jim Moran, Kathelin Gray, Johnny Allen, Bassam Daghestani, Mohammed Jameel, George Richards, David Coulson and the Trust for African Rock Art, Jeffrey and Veronica Berman, Ben and Donna Rosen, Clark Winter, Mauricio Torres Leclerc, Maria Golia, Anthony Sattin, Nicholas Penny, Mark Leithauser, Carole Patey, Michael Snodin, Silvia Davoli, Bill Sherman, Nico Schwartz, Julian Rothenstein, Ahmed Mater, Larry Keith, Jose Luis Colomer, Richard de Tscharner and the trustees of the Carène Foundation, William Ewing, Paula and Jim Crown, Sir Paul and Jill Ruddock, Jonathan and Jane Ruffer, Lindsay Stainton, Pippa Shirley, Juan Manuel Albendea, Casilda Ybarra, Jorge Coll, Ana Debenedetti, Gabrielle Finaldi, Stephen Clarke, The Gentle Author, Ali AlJuboori, Hansi Escobar, Ramon Blecua, Annette Warren Gibbons, Michael Jones, Rut Ballesteros, Rebecca Foote, Dinah Casson, Fabio Roversi Monaco, Richard Terra, People's Palace Projects, Shobita Punja, Sarah Thomas, Daniel Crouch, Fred Hohler, Sir Charles Saumarez Smith, Michael and Sarah Spencer, Aidan Weston Lewis, Nicholas Kugel, Pilar de la Béraudière, Dario Gamboni, Jorge Otero Pailos, Betsy Bolman, Ken Singer, Chiara Casarin, Matteo Lanfranconi, Mario Matthias Wivel, Chance Coughenour, Anna Somers Cocks, Bernardo Tortorici Montaperto, Clare Foster, Clemens Weijkamp and Raymond op het Roodt, Gabriele Finaldi, Jonathan N. Tubb, Phil Harvey, Roberto Grandi, Roger Law, Sarah Thomas, and many others who care about the preservation of the past.

And, of course, everyone at Factum Arte who works tirelessly to support the Factum Foundation and turn its vision into a reality.

This book is dedicated to Pasquale Gagliardi, who first got the ball rolling.

CONTENTS

BEAUTY IN RELIEF

Carlos Bayod Lucini

Carlos Bayod Lucini is an architect and Project Director at Factum Foundation, where he is responsible for the digitisation of paintings and oversaw the recording of the *Polittico Griffoni* (2012–15). He is Adjunct Professor of Historic Preservation at Columbia University and is a PhD candidate at Madrid's Universidad Autónoma, where he is writing a thesis on the relief of paintings.

Lucida 3D Scanner: Manuel Franquelo conceptualised and designed the electronics, mechanics, optics and software. The scanner was fabricated and tested in Factum Arte by Carlos Bayod, Dwight Perry, Jorge Cano, Nicolás Díez, Manuel Franquelo Jr, Guendalina Damone, Enrique Esteban, Marta Herranz and Aliaa Ismail under the supervision of Manuel Franquelo.

OPPOSITE

Scanning the Crucifixion in the National Gallery of Art, Washington, D.C., 2015.

A 15-inch laptop screen may not seem like an ideal window into a painting. The digital image depicts an abstracted version of reality that only bears comparison to the original work of art in some ways. Nevertheless, all eyes were on the screen during the recording of St Lucy (Francesco del Cossa, c. 1473) at the National Gallery of Art, Washington, D.C., in October 2015. The object of rapt attention was an image simulating the painting's relief that was appearing on the screen in real-time.

As the Lucida 3D Scanner moved over the surface of the painting, the data materialising on-screen revealed an image that felt strangely familiar: one could quickly discern the punch marks delineating St Lucy's golden halo and the radial furrows on the golden background. It was also possible to distinguish the figure of the saint and her habit from the surrounding areas, as well as the painting's uneven surface, its subtle craquelure, the slight curvature of the panel, or even areas of paint loss around the edges. The digital image reconstructed the painting's texture by means of light and shadow, with clarity and precision, as though it were an aerial photograph exposing the relief of the Earth's surface.

If one examines a painting carefully, similar three-dimensional elements are usually visible to the naked eye. In a conservation workshop, raking light or a magnifying glass can also help the researcher to better understand surface texture. In a museum gallery, however, relief often goes unnoticed. This may be because paintings are uniformly lit, helping the visitor to see 'properly' from any position in the room. The ideal lighting creates a well-defined image with no shadows, but at the same time the painting is entirely flattened, to the point where it looks like a reproduction of itself. The work of art is thus standardized and packaged for consumption, easily recognizable as its catalogue image or in its multiple other photographic incarnations. Uniform lighting reduces the complexities inherent in the work of art. We may ask, though, whether the artist was in fact relying on textural nuances to produce a variety of aesthetic effects.

In a 15th-century work in tempera on board like del Cossa's St Lucy, textural details beyond the colour are crucial. The artist had recourse to a whole host of techniques that were used to modulate light and create a sense of movement, vibration and space. Punch marks and incisions, the slight differences in depth between the figures and the background… these were the *special effects* that made it possible to express an aesthetic idea on the pictorial surface. To ignore, therefore, the significance of relief in the perception of the work can negate a critical element of the viewing experience. To see the digital 3D image of St Lucy or of St Florian or the Crucifixion (also in Washington) was to appreciate the richness of their relief as if for the first time. The Lucida 3D Scanner, used to digitise all sixteen surviving panels of the *Polittico Griffoni* between 2012 and 2015, was designed specifically to record and reveal the textural qualities of the painted surface.

THIS PAGE

Colour data of the eyes of St Lucy.

OPPOSITE

3D render of the eyes of St Lucy.

The fruit of an exceptional collaboration between the artist Manuel Franquelo, Factum Arte and Factum Foundation, the Lucida is the result of nearly twenty years of research in the field of surface recording. The scanner works by capturing monochrome video of a moving line of light projected onto a surface. The light is emitted by a laser diode and passes through two different lenses (aspherical and cylindrical) to define on the surface a thin vertical line approximately 5 cm long. As the scanner moves parallel to a plane, at a constant distance of 10 cm, the cameras – positioned at 45° to the surface – record the distortions in the laser line produced by the relief. The movement of the linear guides is controlled by an Arduino board and the system is operated using custom software on a laptop. Lucida's structure is modular and easily adaptable to the requirements of each project.

The Lucida has condensed the joint visions of Manuel Franquelo and Adam Lowe about what it is that defines the dynamic nature of a work of art. The complex and constantly evolving surface of a painting speaks to us about its historical trajectory. Painters understand this physicality, as do those who are responsible for safeguarding and conserving works of art. However, the tools to document it accurately have not existed until now. Therefore, a scanner developed by artists to record works by other artists was inevitably going to be based on the following fundamental principle: a painting is *recognised* as much by its material qualities (its relief) as by the image it represents (its colour). Lucida allows us to effectively separate the two aspects, as if we were virtually removing the colour layer in order to look more directly at the object's material qualities. Without the *distraction* of colour, it is easier to see detail in the texture: the marks that denote the passage of time and the indicators of successive repairs and modifications are all revealed in a Lucida scan.

Since a first prototype was released in 2010, Lucida has been used to digitise almost 200 works of art, including paintings, altarpieces, drawings, maps, books, tapestries, decorative objects, tiles, murals, bas-reliefs, sculptures and architectural elements. Objects of various sizes, with diverse origins and from different eras, belonging to both private and public collections around the world, have all been recorded with the aim of contributing towards their conservation, study, or dissemination.

In Summer 2012, three diminutive panels – St George, St Jerome, and St Catherine of Alexandria (Ercole de' Roberti, c. 1473) – belonging to the collection of Vittorio Cini (1885–1977) were among the first paintings to be scanned with Factum Foundation's innovative system. In the Palazzo Cini's art gallery on the Campo San Vio near the Grand Canal in Venice, an early Lucida prototype was used to digitise the almost flat surface of the tiny panels. The 3D scans marked the starting point of the *Polittico Griffoni* digital conservation project; the recording of two round panels depicting the *Annunciation* (Francesco del Cossa, c. 1473) soon followed at the Museo di Villa Cagnola in Gazzada.

Seven years and several dozen projects later, in August 2019, the latest version of the Lucida Scanner was used to document the seven Raphael Cartoons at the Victoria and Albert Museum in London. With a total scan area of more than 120 sqm, this constitutes perhaps the most important 3D recording of pictorial works realised to date. The data resolution is constant at 10,000 points/ cm^2, as is the capture speed at approximately 4 hours/ m^2. These numbers are irrespective of the area recorded: monumental works like the Raphael Cartoons are approached in the same way as the small Venetian panels. There are no shortcuts with the Lucida.

During a Lucida scan, there is plenty of time to contemplate the surface of the painting in question. One can also entertain oneself by watching an undulating line of light glowing white on the black background of the scanning application. With each new photogram, Lucida's cameras record the change in shape and position of the light projected onto the painting – a translation of physical relief into abstract language. Nevertheless, Franquelo, the artist responsible for Lucida's design and software, tends to describe this

THIS PAGE

Colour data of the halo of St Lucy.

OPPOSITE

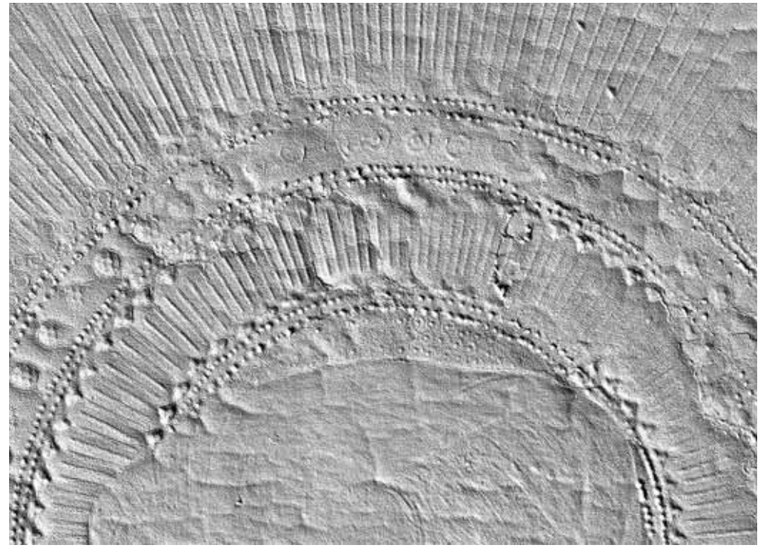
3D render of the halo of St Lucy.

process as the *condensation* of the surface. The term *abstraction* implies simplification, that information is somehow lost. Condensation, on the other hand, is suggestive of information that is being preserved in its most complete, elemental form. In this manner, any relief surface can be documented and stored as a series of ordered profiles.

It is precisely this mode of approaching relief digitisation that makes the Lucida Scanner so relevant within the field of heritage conservation. Whereas most 3D scanning systems automatically perform a transformation on the data during capture, usually to make data processing more user friendly, the Lucida stores *raw* files. This means that in the future it will be possible to access this essential repository of information and re-process the video files with more powerful algorithms than are available today. Implicit in this working method is the current generation's responsibility to ensure that data remains useful even after newer technologies have been developed.

As well as storing the raw video files, the Lucida converts relief into a depth-map – a digital image in which each pixel is assigned a grey tone corresponding to a specific height. Greyscale accurately represents the three-dimensional nature of a scanned surface while allowing a user to work with high-resolution data in a manageable format. Representing three-dimensional information in image form is analogous to seeing in a painting's relief the wrinkled orography of a terrain at reduced scale.

The system was, in fact, designed to digitise flat objects with low relief (maximum depth 25 mm) or what is known as 2.5D – where the X-Y axes that define planar surfaces are fundamentally greater than the Z-axis that establishes depth. Halfway between 2D and 3D, the data captured by the Lucida accurately characterises the original object when the image representing the object reproduces its aesthetic qualities. This is achieved with a different type of digital file, the *shaded render*, which is used to visualise the relief data obtained in the digitisation. The two file types – greyscale depth-map and shaded render – are complementary and serve different purposes. The depth-map enables the



physical reproduction of the surface using digital fabrication means, while the shaded render makes the 3D data visible.

A shaded render can visually reconstruct a scanned surface using the effects of light and shadow. It is generated from the original raw video and based on the simulation of relief using an artificial light source. The light illuminates the scanned 'landscape', creating shadows where it hits the virtual model. The result is an accurate representation of surface texture, very similar to the information obtained when raking light is projected onto a painting. The visualisation imitates reality and the resulting representation of the relief is therefore intuitive, readable and inherently beautiful: a monochrome image composed of light and shadow that establishes a direct correspondence with the visual appearance of the original object. It is subjective in the sense that it is created artificially and *digitally mediated*, but it is also an essentially objective, quantifiable reconstruction of reality. As such, a Lucida shaded render is also a snapshot of an artwork's state of conservation at a concrete moment in its historical trajectory. This constitutes the primary function of the Lucida: it is most useful as a system for documenting objects of cultural and artistic heritage, especially during conservation processes.

The central panel of the *Polittico Griffoni*, St Vincent Ferrer (Francesco del Cossa, c. 1473), was recorded at the National Gallery in London in 2013. The painting had been conserved in the 1980s, when its support was changed to balsawood, the curvature flattened, and the surface cleaned in a process that returned intensity to the colour. The *National Gallery Technical Bulletin* describes, for example, how following treatment the form of the saint's black habit became more distinct and the colour of the sky more vivid.[1] The 3D scan of the painting revealed a surface in a good state of conservation, with few areas

1 Alistair Smith, Anthony Reeve and Ashok Roy, 'Francesco del Cossa's *S. Vincent Ferrer*', *National Gallery Technical Bulletin*, vol. 5 (1981), 44–57, http:/ / www.nationalgallery.org.uk/ technical-bulletin/ smith_reeve_roy1981.

of damage or paint loss beyond the borders (except for an area on the face that required significant remedial work). The figures' contours are clearly distinguished by the subtle height difference in relation to their surroundings. This variation is particularly evident in the uppermost area of the panel, in which the figures emerge from a golden background. The characteristic punches surrounding Christ and the angels' halos were used by the artist to generate the effect of light bouncing off the surface of the gold, part of the delicate play of depth and texture that completes the viewer's perception of the work.

The predella, *The Miracles of St Vincent Ferrer* (Ercole de' Roberti, c. 1473), was also scanned in 2013 in the Pinacoteca Vaticana; it presented an entirely different state of conservation to the National Gallery panel. The data exposed a succession of linear cracks along the central axis, corresponding to the wooden frame that was fitted to the back. The 3D scans created a precise and detailed record of the state of the surface of the panels revealing the need for the attention of the restoration team. The dynamic character of the support was causing the brittle paint layer to crack and lift. The ability to inspect the surface with and without colour adds another layer of complexity to the photographic documentation. The benefits of using the Lucida to monitor change in a work of art before and after conservation treatment became evident in the case of the St Peter and St John the Baptist panels (Francesco del Cossa, c. 1473), which belong to the Pinacoteca di Brera in Milan. The first scan was carried out in 2014 and later used as a base for the facsimiles. Two years later, following restoration and surface cleaning at the Barbara Ferriani studio in Milan, the panels were scanned a second time; the repairs and superficial stabilisation were clearly visible when comparing the scans from before and after the restoration.

High-resolution 3D recording allows one to look at a work of art without being distracted by its colour. As in a bird's-eye view of a landscape, the geographic accidents of

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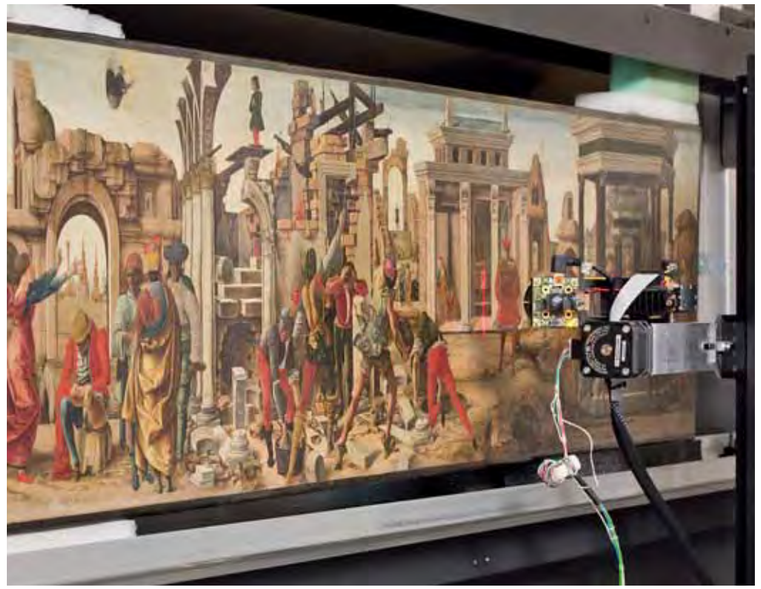
Recording the predella at the Pinacoteca Vaticana, Vatican City.

OPPOSITE

Carlos Bayod Lucini recording Francesco del Cossa's Crucifixion, 1472–73, at the National Gallery of Art in Washington, D.C.



a painting are revealed in the greyscale image and its visual interpretation using light and shadow. One can only begin to intuit the complexity of the pictorial surface when one understands that a painting is more than a flat image – it is in all respects a three-dimensional object where each groove corresponds to the physical imprint of the events that have shaped its appearance. When these three-dimensional traces are made apparent in the scan data, they can generate new questions about the work of art. The 3D recording of paintings and other low-relief objects is a relatively recent and quickly evolving method of documentation and analysis. The Lucida system is a reference point in the field of 3D scanning whose development has paralleled the digital reconstruction of the *Polittico Griffoni*. Since the digitisation of the panels began in 2012, interest in the technology from conservators and heritage practitioners has grown exponentially because, beyond the capability to physically reproduce a work of art, Lucida data makes it possible to study the detail of a painted surface on a computer screen – a unique and novel experience in the world of art.

The surface of a painting reveals much about the artist's intention and aesthetic conception of the work. Texture can produce exquisite effects of light and shadow that complement colour as a vehicle for the transmission of the artist's ideal of beauty. A method of digital mediation that translates surface into an image created from light and shade results from the determination to faithfully convey the unique character of a painting's relief. A system like Lucida, created by artists to record and reveal the beauty of the painted surface, necessarily creates aesthetically appealing images. Beyond its usefulness for forensically accurate documentation, there is a seductive aesthetic in the renders themselves that invites an intimacy with the object. The Lucida's success is based upon its capacity to reveal the aura's physicality.