Johann Habakuk Israel /
Christian Kassung / Jürgen Sieck (Hrsg.)

Kultur und Informatik: Extended Reality

Multimedia

vwh

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Extended Reality

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Verlag Werner Hülsbusch
Fachverlag für Medientechnik und -wirtschaft

J. H. Israel*/C. Kassung**/J. Sieck*/** (Hrsg.):
Kultur und Informatik: Extended Reality

Anschriften der Herausgeber:

* Hochschule für Technik und Wirtschaft
FB 4, Forschungsgruppe INKA
Wilhelminenhofstr. 75a, 12459 Berlin

** Humboldt-Universität zu Berlin
Exzellenzcluster „Matters of Activity. Image Space Material"
Hermann von Helmholtz-Zentrum für Kulturtechnik
Sophienstraße 22a, 10178 Berlin

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet unter http://d-nb.de abrufbar.

HUMBOLDT-UNIVERSITÄT ZU BERLIN

Gefördert durch
DFG Deutsche Forschungsgemeinschaft

Die Herausgeber danken für die Unterstützung des Exzellenzclusters *Matters of Activity. Image Space Material*, gefördert durch die Deutsche Forschungsgemeinschaft (DFG) im Rahmen der Exzellenzstrategie des Bundes und der Länder – EXC 2025 – 390648296.

vwh Verlag Werner Hülsbusch
Fachverlag für Medientechnik und -wirtschaft

www.vwh-verlag.de

Umschlag: design of media, Lüchow
Druck und Bindung: SOWA Sp. z o. o., Piaseczno

Printed in Poland

– Als Typoskript gedruckt –

ISBN: 978-3-86488-169-5

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Augmented Reality and Renaissance Painting

An AR Experience for the Fitzwilliam Museum in Cambridge

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Abstract

This conference paper aims to demonstrate the effectiveness of Augmented Reality technology as a powerful tool for communication and dissemination of Cultural Heritage. The case study examined in this paper is an Augmented Reality (AR) app designed for the Fitzwilliam Museum in Cambridge (UK). The app, called *Ways of Seeing*, conveys to the public conservation reports and non-invasive technical analysis about an Italian Renaissance artwork, created in the 15th century by the Florentine painter Jacopo del Sellaio. Using this kind of Extended Reality interactive digital interpretation, museums can bridge the gap between scholarly research and public knowledge, giving accessibility to a largely unknown set of facts.

1 Introduction

Augmented Reality is rapidly and progressively gaining widespread use and popularity in a vast range of fields [Mani16]. Publishing, healthcare, engineering, gaming, and many more vital industries of our modern world rely on visualisation and communication technologies that could exploit the benefits associated with AR. Very popular smartphone apps, like *Pokemon Go*, and – more recently – features of Google services like *Translate* and *Maps*, have contributed over the last two decades to disseminate the basic principles of AR technology, which is now growing in terms of numbers of active users and developers specialized in its design and implementation [Mand19]. In addition, research teams all over the world have contributed to the spread of the knowledge on this field with an ever growing range of academic publications illustrating techniques, best practices, and refining theoretical frameworks for the use of AR for the enhancement of the Cultural Heritage [Comm12] [Empl15] [CaBr17].
In this paper I explain how AR has been used as a powerful tool to communicate very complex technical and conservation information relating to a masterpiece of the Italian Renaissance held in the Fitzwilliam Museum, in Cambridge[1]. Using this particular approach, onsite visitors can access an unprecedented quality and amount of technical information not generally available to the public [NeEg17]. Innovative and unobtrusive user experience design makes this experiment user friendly and interactive, allowing museum visitors to engage with the painting in a compelling and critical way. As we will discuss, this type of digital experience, using a site-specific installation, can be used to complement both temporary exhibitions and permanent collection settings.

2 The Focus Painting

2.1 History and Context

The focus of this digital experience is a Florentine artwork, painted around 1473 using tempera and gold on a wooden panel, depicting the mythological subject of *The Story of Cupid and Psyche*. The artist is Jacopo del Sellaio (born 1441– died 1493), a prolific painter active in the second half of the fifteenth century [Fahy89] (Fig.1). It is a painting of a considerable size, measuring 58,6 cm in height and 178,8 cm in width. Its format, low and wide, along with its profane subject, suggests that it may have been originally a part of a *spalliera,* a typical Renaissance furnishing element serving as a backrest, often decorated with paintings. Spalliere also had a thermal function, insulating the internal walls of homes from the external cold and damp. If not a spalliera panel, the Cambridge painting may instead have been the frontal panel of a *cassone*, a genre of storage chest, usually found in Medieval and Renaissance bedrooms and decorated with scenes painted with tempera and gold [Mizi19].

1 https://www.fitzmuseum.cam.ac.uk/, last accessed 05/03/2020.

Fig. 1: Jacopo del Sellaio, *Story of Cupid and Psyche,* c. 1473. Cambridge, Fitzwilliam Museum.

The Fitzwilliam painting portrays the first half of the *The Story of Cupid and Psyche,* a common subject for bridal chests in Renaissance Florence. The story, which has a deep allegorical meaning, is the mythical romance of the mortal princess Psyche with Cupid, the God of love and son of Venus. The first panel depicts the beginning of the tale, beginning with the episodes of the birth of Psyche and Cupid falling in love with her. The development features a complex plot of deceptions and riddles involving the other major characters of this story: Psyche's suitors, sisters, and parents [Vert79]. Another painted panel, now held in a private collection, shows the second half of the story and its happy resolution with Psyche's marriage to Cupid, and has also been identified as a work by Jacopo del Sellaio. As the dimensions are nearly identical, it seems certain that this second painting formed a pair with the one in the Fitzwilliam Museum [Kroh08]. At a time when most art was religious, secular romance subjects such as the *Story of Cupid and Psyche* were generally associated with

marriage [Vert93]. Therefore, this pair of painted panels could have been commissioned on the occasion of a wedding between wealthy Florentines, and also paraded through the streets of the city to display the status of its patrons [Call98].

Sellaio's painting, part of the permanent collection of the Fitzwilliam Museum, is normally displayed in the Upper Marlay gallery, with other Italian works from the 13th to the 15th century. It is currently the centrepiece of the *Inspire 2020* exhibition curated by Kate Noble, held in the Octagon gallery of the Fitzwilliam Museum (10 December 2019-22 March 2020)[2]. *Inspire 2020* showcases primary school children's artworks inspired by and responding to Sellaio's painting. Over the course of 2019, 3,800 children and teachers researched and studied the painting in schools across Cambridgeshire, producing numerous drawings, paintings, sculptures, and installations, a selection of which are displayed within the Octagon gallery in dialogue with the Renaissance artwork.

2.2 Technical Analysis and Conservation

The children's own research into the materials and techniques used by Del Sellaio in his Renaissance workshop prompted the Fitzwilliam's experts to carry out their own research on the panel. In order to check the painting's condition and to undertake scientific analysis, the panel was transported to the Hamilton Kerr Institute (HKI), the paintings conservation department of the Fitzwilliam Museum[3]. Dr Paola Ricciardi, Fitzwilliam Museum's Research Scientist, and Vicky Sutcliffe, Paintings Conservator at HKI, captured technical images of the painting and undertook a full non-invasive investigation of the painting's materials over the course of two weeks. The technical images obtained include infrared reflectograms, microphotographs, and X-ray scans. All these technical analyses are non-invasive, i.e. they do not require sampling of material from the wood support or the paint layers. The painting was deemed to be in good overall conservation condition, and the painted surface was lightly cleaned and consolidated before the start of the exhibition. Also, the painting was glazed with a thin anti-glare glass to protect it from physical damage and sudden thermo-hygrometric variations.

2 https://www.fitzmuseum.cam.ac.uk/calendar/whatson/inspire-celebration-childrens-art-response-jacopo-del-sellaios-cupid-and-psyche, last accessed 05/03/2020.

3 https://www.hki.fitzmuseum.cam.ac.uk/, last accessed 05/03/2020.

These technical imaging methods were very helpful for the study of the painting from an art historical and also technical point of view. Pigment analysis was coordinated with microphotography, while the X-ray scan revealed the presence of canvas patches under the gesso ground and nails within the panel structure.

The most interesting information was obtained from infrared scanning. Thanks to this imaging technique, it is possible to clearly identify later retouching, but also, more importantly, preparatory underdrawings made by the artist below the final layer of paint. The infrared image shows clearly an abundance of underdrawings, made with ink and pen, all over the painted surface. For instance, the artist worked out the flying Cupid's final position making several adjustments to the arrangement of his wings and feet. Evidence provided by the infrared frequency imaging means that it is also possible to see underdrawings that were initially outlined by the artist, but then were left out from the final composition. These are the figure of Cupid, armed with his bow and standing in a niche in the façade of his palace on the right-hand side of the scene, and three other figures (probably Psyche herself and her parents) bowing to the statue of the oracle in the temple in the left-hand side background. These elements are not visible to the naked eye, as the artist decided not to include them in the final composition, and are therefore covered by an opaque layer of tempera paint.

The range and the results of the technical analysis executed by the Fitzwilliam's conservators and scientists are discussed in a separate publication [CoNo20], but from this brief summary it is possible to appreciate how the findings shed light on the process of creating the artwork from its material wooden support to its final execution. High-resolution microphotographs, infrared, and X-ray scans are suitable for presentation to the public in a visual form, as they carry a good level of detail which allow the user to appreciate the aforementioned features below the visible painted surface [Bruz13]. Furthermore, this technical data is rarely disseminated to a broad public, and a traditional form of interpretation display, such as a text panel, can be perceived by the public as too complex or intimidating. The particular affordances of AR, however, offer new ways to bring the scientific analysis of paintings into the gallery space.

3 The *Ways of Seeing* AR App

3.1 Partnerships and Multidisciplinarity

Ways of Seeing is the product of an international and interdisciplinary partnership between several institutions. Art historians, museum educators, conservators and scientists, digital specialists and software developers have all contributed in different ways to this project, with a multi-faceted approach. The development of the app was funded by the Arts and Humanities Impact Fund and the Department of History of Art at the University of Cambridge, and has been carried out by Maggioli Group, an Italian IT company based in Florence. Concept, design, and development of the app were structured as a research collaboration between the Fitzwilliam Museum, the Department of History of Art at the University of Cambridge and the SAGAS (Department of History, Archaeology, Geography, Art, and Performing Arts) at the University of Florence.

To create the app, the author (currently a PhD candidate at the University of Florence), and Dr. Donal Cooper, Senior Lecturer in Italian Renaissance Art at the University of Cambridge, worked together with colleagues at the Fitzwilliam Museum and the developers at Maggioli Group to integrate the new research within an effective user experience, which exploits the potential of mobile-based augmented reality to encourage visitors to look more closely at the original painting. The author was the project manager, coordinating and organizing the work between all the different teams and university departments involved in Cambridge and Florence[4]. Without this degree of close collaboration between the different units, it would not have been possible to design, develop, and test the software in the short time frame of the project (December 2019 – February 2020).

4 Concept, design and development of the Ways of Seeing app are the work of Giovanni Pescarmona (University of Florence) and Marcello Massidda (Senior developer, Maggioli Group). Research on the painting, text content included in the app, and design of the user experience are a joint work of Giovanni Pescarmona, Donal Cooper (University of Cambridge), Kate Noble (Fitzwilliam Museum), Daniel Pett (Fitzwilliam Museum), Paola Ricciardi (Fitzwilliam Museum), Rosanna Evans (Fitzwilliam Museum), Elsbeth Geldhof (independent conservator), Vicky Sutcliffe (Hamilton Kerr Institute), and Chris Titmus (Hamilton Kerr Institute). Filippo Fineschi coordinated the project at Maggioli Group.

3.2 Concept, Design and Development

The App *Ways of Seeing* runs on low-end Sony smartphones owned by the Fitzwilliam Museum that can be borrowed free of charge by Museum visitors in the gallery. Two smartphones are kept beside the painting, where visitors can use them independently. Framing Jacopo del Sellaio's painting with the smartphone camera, the device overlaps the real image with virtual elements. In doing so, the user enjoys an empowered vision, and can identify features within the artwork that are not visible to the naked eye, such as the underdrawings made by the artist, the structure of the wooden planks, or the microscopic texture of pigment brushstrokes (Fig. 2).

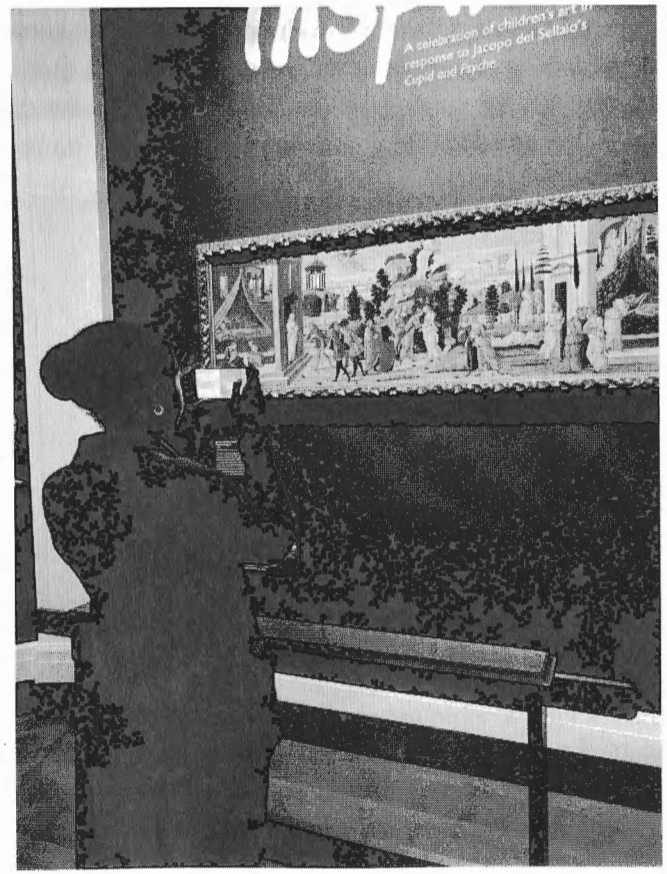

Fig. 2: *Ways of Seeing* app in use in the Octagon Gallery. Fitzwilliam Museum, Cambridge.

The basic functionality of the app allow the user to "see through" the painting to access technical and conservation information. To achieve this, AR technology is used to overlay a computer-generated image on top of the real environment, creating a perceptual illusion. The user can see "through" the painting, visualising three layers of digital images (microphotography, infrared, and X-Rays), experiencing a sense of progressive zooming into and below the visible surface.

To create a strong perception of identity between the digital image rendered on the device and the real object that is in front of the user for the whole duration of the experience, a very accurate alignment of the computer-generated image with the real object was needed. In order to achieve this technical specification, the *Ways of Seeing* app has been developed using the marker-based Vuforia Software Development Kit (SDK), allowing high levels of detail and smooth graphic rendering. The Vuforia SDK has been implemented within the Unity game engine platform for the creation of the structure of the app (Fig. 3).

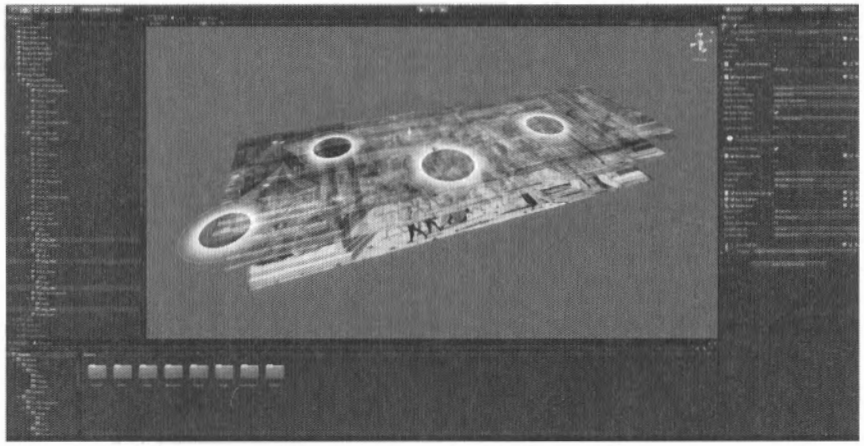

Fig. 3: Screenshot of the *Ways of Seeing* project viewport on the Unity game engine.

The image of the painting has been assimilated to a perfectly flat 2-D image, and it has been used to create a *marker*, giving 3D coordinates for correctly orienting and placing the virtual elements in relation to the real environment. Then, a virtual layer has been created with each one of the three types of technical imagery (microphotography, infrared, and X-Rays). Each one of these three images constitutes one of the three "modes" of the app, and represents the core of the user experience, each one offering a set of interactive elements.

The interface displays, on the lower part of the screen, a simple touch bar, or "navigator", showing the titles of the three modes: *Microscopy*, *Infrared*, and *X-Ray*. By tapping on one of these three words, the correspondent mode is activated. A virtual image, showing the selected technical data, will appear with an animation effect, and is superimposed at a 1:1 scale over the painting. Zooming levels on the images are synchronised on the hand held device with the user's movements when held up to the original painting, and help create the effect that the smartphone itself is doing the scanning work in real time. The recognition rate of the Fitzwilliam painting by the Vuforia SDK software is very high, a fact allowing the user to get very close to the painting, to a limit of 10 cm from its surface. This translates into a very stable and high-quality experience, with little or no trembling or shaking of the virtual elements, and a considerable amount of freedom of movement for the user, who is free to frame the artwork, explore its features, pause and then start again, with ease and without frustration.

The user interface has been designed keeping in mind an expected user-time by visitors of about 2–6 minutes. Therefore, the team decided to minimise the number of buttons, switches, and sliders of the user interface, with the aim of creating the most intuitive and self-explanatory experience as possible. Theoretically, users do not even need to read the instructions provided in the interpretation panels on display in the gallery to correctly engage with the app, and first-hand feedback on the digital experience (which is currently still ongoing) seems to confirm this assumption.

3.3 Curated Content

While scanning the painting with the device camera is by itself an engaging and revelatory experience, the team working on the app concluded that a curated form of content was needed in order to offer a more in-depth exposition of what technical analysis can tell art historians and conservators about Renaissance art. We also wanted to convey this data in an engaging and interactive way, without forcing the user to pass through an obligatory path of subsequent steps to follow [Vild17]. This was a complex problem to solve, as there were many conflicting design priorities, and we

had to pass through many iterations of prototyping, testing, and correction to get to the final result.

The compromise we agreed on is to select for each one of the three modes a total number of four Points Of Interest (POI) marked by white circular hotspots (HS), as shown in Fig. 4. Each one of these is an interactive element: by tapping on it on the surface of the touchscreen, the user is provided with an info sheet, carrying a magnified detail image of the selected point of interest along with a concise descriptive text. We set the maximum length of all the texts in the interactive info sheets to 300 characters, including spaces, to provide essential but also digestible knowledge about every POI. The hotspots appear and disappear rhythmically with a gradual fade-in and fade-out effect every four seconds. This solution was chosen in order to allow the user to appreciate the whole technical image without any form of distraction and, at the same time, to guide the user by presenting curated content for the most meaningful information emerged from each one of the three chosen technical images. These include: for microphotographs, details of liquid gold, and various types of different pigments used to create shading and highlights; for infrared, sketches made by the artist to figure out the position of anatomical elements, or characters that were sketched, but not included in the final composition; for X-rays, wormholes, metal nails in the wooden support, and pieces of canvas fabric to protect the painted surface.

Also, for each one of the three modes, a general info sheet is provided with information about the scientific technique used to produce the image, and can be accessed by tapping the info button on the top right-hand side corner of the touchscreen. Using smartphones owned by the Fitzwilliam Museum allowed a quicker development time, as there was no need to create a responsive user interface with a flexible layout capable of detecting the visitor's touchscreen size and change accordingly. The experience is also more user friendly, as visitors do not have to download any app on their personal smartphone. In the future, it would be possible to expand the project by creating a free downloadable app that could be used outside the Museum setting, maybe using a printed image as a marker for the AR experience, and including more artworks in the digital platform.

A hidden analytics page can be accessed by the Museum's team, and has been developed to gather non-personal data to assess the impact of the app and how people tend to use it. Each smartphone tracks the total usage

time in *Explore mode* (that is while the camera is rendering the AR images), the total number of *Sessions* (each time a user activates the app), and the total number of *Tracked Markers* (each time a user frames the painting with the camera, action that can be performed multiple times within a single session). Data gathered so far during the short period of deployment, however, is as yet insufficient to draw solid statistical conclusions from the analytics panel, but visitor services at the Fitzwilliam Museum have gathered positive spontaneous feedback from the users, highlighting how the digital visualisation tool helped them in looking in a new way at a Renaissance painting.

Since the marker recognition is not very sensitive to the lighting conditions and the glazing of the artwork, given the good recognition of the marker, the app could still be used to encourage visitors to engage with technical data as an integral part of their gallery experience when the *Inspire* exhibition ends and the painting returns to the permanent collection of the Fitzwilliam Museum.

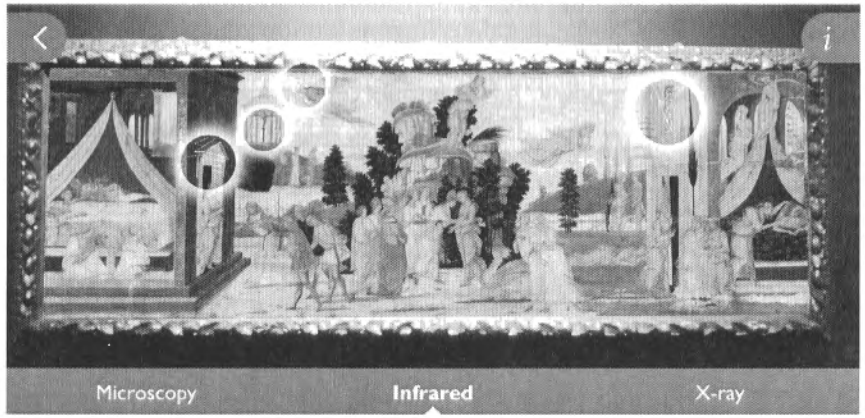

Fig. 4: Screenshot of the *Ways of Seeing* app running on the Sony smartphone. The *Infrared* mode is selected, and the four white circular hotspots are shown on the virtual image.

4 Conclusion

This type of multimedia experience represents an important addition to the visitor experience at the Fitzwilliam Museum, complementing the *Inspire 2020* exhibition and, in the future, the permanent collection in the Upper Marlay Gallery. The AR app provides a powerful, engaging and meaningful experience through an accessible medium, conveying information that is not easily communicable with traditional forms of display. In a future phase of the project, feedback left by the visitors will offer valuable insights, enabling an assessment of the impact of the app and elements to improve, moving towards an experience that can be also accessed remotely, outside the museum. In conclusion, this paper explored how applications like *Ways of Seeing* can close the gap between technical analysis, scholarly research and public knowledge, raising the awareness about the methods and practices of technical art history. An Extended reality approach of this kind, while technologically simple, can be very effective for communication and dissemination purposes for museums, galleries, and cultural institutions worldwide.

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Multimedia

Extended Reality (XR) is omnipresent and will become even more important in the future. Therefore, XR was the main topic of the conference *Culture and Computer Science 2020*.

XR encompasses augmented, mixed and virtual reality as well as all intermediate forms. In the articles in this book, many theoretical aspects are discussed and best practice examples from art and culture are presented.

Extended Reality (XR) is characterised by a significant degree of interdisciplinarity. The entanglement between the real world and computer-generated data cuts across and expands far beyond disciplines such as human-computer interaction (HCI), computer graphics (CG), sensor systems, machine-to-machine communication, cultural science and design.

This volume addresses cultural policy makers, employees of cultural and creative industries, communication scientists, cultural and artistic actors as well as computer scientists and engineers, who conduct research and development in the field of Extended Reality.

Matters of Activity Image Space Material

DFG Deutsche Forschungsgemeinschaft German Research Foundation

The editors acknowledge the support of the Cluster of Excellence *Matters of Activity. Image Space Material* funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2025 – 390648296.

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29,80 € (D)
30,64 € (A)
35,80 CHF

vwh Verlag Werner Hülsbusch
Fachverlag für Medientechnik und -wirtschaft

ISBN: 978-3-86488-169-5