THE IMPORTANCE OF INTEROPERABILITY OF DIGITAL PHOTOGRAPHY AND BEYOND

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RESUM

La fotografia computacional és cada cop més important en recerca i difusió. Iniciatives com l'International Image Interoperability Framework (IIIF) i el requisit general de dades obertes són tendències que mostren la importància de l'intercanvi estandarditzat de dades i la importància de la col· laboració en els espais digitals.

Tanmateix, com més complexes i interactives siguin les dades d'imatge, més meta-informació tècnica es necessita per poder representar, intercanviar i interpretar amb èxit aquestes dades d'una manera significativa.

En aquesta ponència s'explicaran els principis bàsics de l'IIIF, però també es mostren els límits de l'estàndard. S'expliquen les possibles solucions i es redacten el potencial i les aplicacions. Es tenen en compte temes com la interpretació del color, la configuració de l'escena i les capacitats d'anotacions.

RESUMEN

La fotografía computacional es cada vez más importante en investigación y difusión. Iniciativas como el International Image Interoperability Framework (IIIF) y el requisito general de datos abiertos son tendencias que muestran la importancia del intercambio estandarizado de datos y la importancia de la colaboración en los espacios digitales.

Sin embargo, cuanto más complejos e interactivos son los datos de imagen, más metainformación técnica se necesita para poder representar, intercambiar e interpretar con éxito estos datos de una forma significativa.

En esta ponencia se explican los principios básicos del IIIF, pero también se muestran los límites del estándar. Se explican las posibles soluciones y se exponen el potencial y las aplicaciones. Se tienen en cuenta temas como la interpretación del color, la configuración de la escena y capacidades de anotaciones.

Trends in Digital Humanities

The Digital Humanities deal with digitisation in social sciences, arts and humanities disciplines [1]. Even more, than in other fields of science, research in the humanities uses existing sources. This already mastered research work is mainly available as monographs, in other publications or as objects, and artefacts. Getting access to this source material can be difficult or limited. The transition to the digital domain promises easy access to the material. The internet is vital in this context. However, technology is advancing fast, and data, as well as methods and research tools, do develop rapidly. New formats and methods arise, and others disappear. It is a challenge for digital infrastructures, like databases, to handle the richness of data files, and it is also a challenge to use the provided datasets in a meaningful way [2].

Open data is a must in research; therefore, open repositories have become very important [3]. Metadata formats have become a research subject by themselves, and digital preservation strategies are necessary to provide the fundament for any digital citation [4].

Photography is still an important way to illustrate the richness as well as specific research questions and details of artefacts [5]. Improved metadata helps to understand the meaning, origin, context and quality of the data provided. Technologies like 3D scanning and methods from computational photography are already crucial for research in various humanities disciplines. The way of looking at digital image data has changed. High-resolution images allow us to get strong magnification, and clustering large assets of images enables new ways of distant viewing [6].

Standardisation is an important issue because humanities research is more interdisciplinary today and results from teamwork instead of individual efforts more than ever. Standardisation is essential for any kind of data science to access and load data from various repositories. Exchanging data in a standardised way with other repositories or between backends and frontends enables the use of data with different applications and interconnecting different machines to analyse data automatically. To describe the exchange of data between such parts of a network, the term "interoperability" has been established.

Interoperability means data can be exchanged and reused for any application in a digital system. FAIR data reduces these requirements to the maximum: Findable, Accessible, Interoperable and Reusable data is fundamental for any scientific application in a network of servers and clients [7]. To access data stored on a server, an interface is necessary. The interface is the gate to the server. Because the interface offers some well-defined functionalities, it is called Application Programming Interface, API. APIs have their origin in software development. Software is usually structured in different layers and components. These elements do communicate with each other and allow for exchanging functionalities. The API is a small software that listens if a request is sent from another element or, in the context of the internet, a client computer. Usually, such requests are running on the internet. The internet is a network that requires standardised communication. Such a request might, for example, look like this: *https://143.234.12.114/data/projects/123422/23122/product?sku=12345*

This URL (Unique Resource Locator) comprises an IP address, specific project information and a parameter that is not documented in the above example. Without the necessary documentation, such an URL can not be fully understood.

Standardisation is necessary in this case, and a widely used standard for such network requests to receive images is provided by the International Image Interoperability Framework (IIIF.io). IIIF emerged in 2011 with support from the Mellon Foundation (https://mellon.org/), a joint initiative of renowned memory organisations, including Harvard University, Stanford University Libraries, Cornell University, the British Library, and the Bodleian Library (Oxford), and the national libraries of France and Norway. Today, the IIIF community is supported by numerous museums, libraries, and archives spread across the globe [8].

International Image Interoperability Framework

The advantage for the institutions that use IIIF is that by using the standard, they can access the large set of tools that have been developed around IIIF and are constantly being developed further. This means, for example, that not every library has to worry about programming its image viewer. This is because all images compatible with the IIIF interface can be viewed with an IIIF-capable viewer, which is available as open-source software on the Internet. This also has some advantages for the users. For example, we can view an image in high resolution in the viewer of the Getty Museum in Los Angeles and simultaneously insert another one from the National Gallery London. The images can now be viewed side by side in detail and compared without having to download. The fundamental idea of the APIs of IIIF is to provide a well-documented standard for accessing digital images and the corresponding metadata.

The IIIF standard is composed of various specific APIs. Two significantly important APIs shall be mentioned: The Image-API, which returns an image, and the Presentation-API, which delivers metadata. The result of the Presentation-API is also called manifest. It contains metadata and can be considered a recipe for presenting images. In addition to the title of the image and the image size, it can also contain annotations. Besides the Image- and Presentation-API, the IIIF standard defines, the Content Search API that enables search queries within an IIIF resource, the Authentication API that allows regulating access to IIIF resources, the Change Discovery API provides information about object changes, and the Content State API generates links to objects in specific states.

Let us have a closer look at the process of getting such images. The images are usually stored in the format JPEG2000 in maximum resolution on the server. While requesting the images, various parameters can be set to receive the data in a customised way. Images can be requested,

- → with a specific region
- → rotated
- → resized
- → in reduced quality
- → in some formats

The necessary URL look generalized like this, {scheme}://{server}{/prefix}/{identifier}/{region}/{size}/{rotation}/{quality}.{format}

or as a specific example like this, if the image is requested in full size, without rotation as JPEG image data file in colours, *http://www.example.org/image-service/abcd1234/full/full/0/default.jpg* or as an example, 45 degrees rotated and in 50% size and decimated to only grayscale, *http://www.example.org/image-service/abcd1234/full/pct:50/45/gray.jpg*

Figure 1 shows how the parameters must be ordered to get the result as expected.

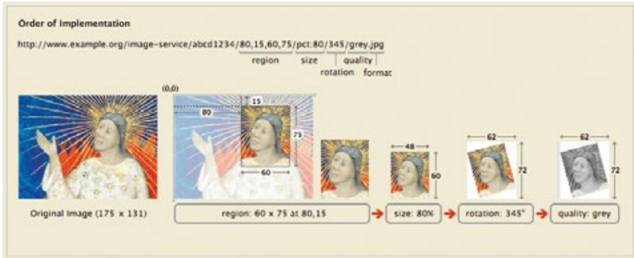

Fig 1: The IIIF-Parameters and what they do with the image data. https://iiif.io/api/image/1.0/images/iiif-order.png

More details can be found at the IIIF site (*https://iiif.io/*) where all the documentation can be found.

IIIF's standardised interfaces are a great advantage. Another advantage is a large number of applications and the size of the community. Today, many repositories already offer an IIIF interface. This allows access to digital image content, which is advantageous for research work in the humanities. Various tools to view, compare and annotate images can be used without developing them (Fig. 2).

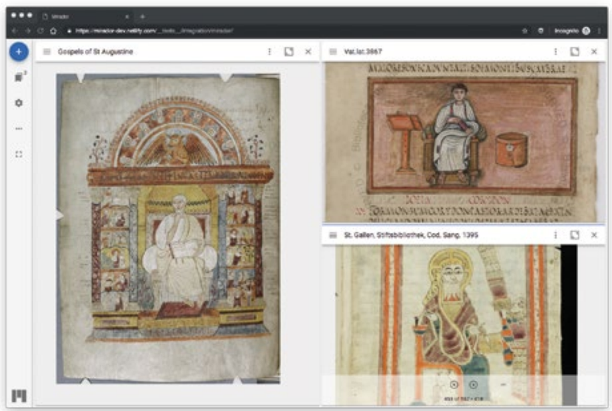

Fig 2: The IIIF-compliant Mirador viewer shows three images originating from different repositories. https://library.stanford.edu/sites/default/files/blog/image/mirador3blogimage.png

Interoperability, Computational Photography and 3D

Access to digital resources is beneficial and essential in the context of today's digital humanities. The possibility of accessing image data and their metadata is necessary for the machine analysis of image material and data science. However, many areas of image-oriented humanities have a trend toward interactive image content. 3D representations are increasingly common in architecture, archaeology, but also in historical research and art history.

The analysis of image data is also crucial in computational photography. Thus, statistical evaluations can be carried out via API access, colours can be analysed, and image content can be evaluated. Therefore, it is essential to observe the corresponding standardisation in the field of formats in computational photography and support it through one's participation. IIIF has also been working to define standardisation in interactive image formats. The IIIF 3D community writes on its website:

> *"The 3D community group provides an opportunity for institutions interested in interoperability to coordinate strategies and facilitate conversations about open standards that support 3D use cases. Many of the desired operations and interactions with 3D data are similar to the 2D, and A/V use cases of IIIF for sharing images and annotation, and organisations are increasingly looking to integrate exhibits, displays, and comparisons of 3D data with other file types."* [1]

The complexity in the area of 3D image data is significantly greater than with standard images. In the claim of 3D, an entire scene is defined as composed of the object, the camera, one or more light sources and an environment. The parameters that can be selected when loading the data in question are much more extensive. Here, too, there is still a lot of development, and above all, file formats for storage need to be defined. Various workgroups take care of format definitions, but formats defined by commercial vendors are also being discussed. However, a convergence as with the TIFF and JP2K image formats in the case of 2D image data is not yet apparent. It's interesting to follow, for example, the discussions of the DigitalPreservationCoalition that is giving recommendations for archival file formats[2], or the Library of Congress[3].

At the Digital Humanities Lab of the University of Basel, scientific photography is an important topic [9].

As the DH-Lab traditionally combines photographic capturing and digital archiving processes, we focus on generating 3D photographic visualisations that will align with the discussion about 3D standards that will, let by the IIIF consortium, define the criteria for the exchange on 3D digital data. Today's DH-Lab emerged from the Department of Scientific Photography of the Faculty of Science at the University of Basel. In the first half of the 20th century, research into analogue film materials was just as important as developing and applying special photographic processes. With the end of analogue photography, the natural science-oriented group was transferred to the humanities. Since 2001, it still studies, reflects and researches image formation, image storage and image use, as this is one of the most important visual research data for arts and humanities.

Project Digital Materiality

In collaboration with the Art History Department of the University of Basel, a method for measuring and representing the material properties of medieval mosaics was developed between 2015 and 2018. The research work was based on Reflection Transformation Imaging (RTI) [10]. The aim of the project was the improvement of the diverse materials used in the mosaics. The approach was, using a data-driven scientific method to find a better model or a combination of multiple models to reproduce Lambertian (matt) and specular (glossy) materials with as few parameters as possible.

WebGL, a subset of the well-known graphics library "OpenGL", was used to render RTI images in any standard web browser, even on most mobile devices. Such a solution opens various new applications and allows for collaborative work because the viewer can be embedded in any modern Web environment embedding RTI in Virtual Research Environments (VRE) for annotation and interlinkage of multiple originals stored in one or more repositories.

1 - https://iiif.io/community/groups/3d/

2 - https://www.dpconline.org/blog/bit-list-blog/exploring-3d-file-formats

3 - https://www.loc.gov/preservation/resources/rfs/design3D.html

The project was completed successfully, and parts of the software could be continued and commercialised by the start-up company TRUVIS AG (www.truvis.ch). The necessary hardware is manufactured and distributed by Bron Electronics AG in Switzerland (https://broncolor.swiss). Figure 3 shows the light dome necessary for image capture and the Truvis Authentica software that calculates and visualizes the surface models that can be digitally reilluminated.

Fig. 3: Bron Scope Lightdome powered by Truvis Authentica. https://broncolor.swiss/assets/img/Products/Light/Surface-Visualizer/_storyTeaser13/Scope-D50-Reflectance-transformation-imaging-RTI-dome.png

Even if the Truvis/Bron solution offers a high degree of interactivity, it has its limits. The resulting image is still a bitmap, a dataset represented as a 2D image. For various applications accurate 3D data is of advantage or necessary. The various modern methods of computational photography only cover individual aspects of importance in humanities research. Unifying different technologies like 3D Photogrammetry and RTI approaches in image acquisition, as well as image storage and transmission, would be ideal. For example, the mesh of a 3D image is difficult to assess in terms of the precision and validity of the data if looked at details of the reproduced artefact [11]. On the other hand, a Reflection Transformation Imaging dataset is interactive, but the data basis is a bitmap, which cannot truly represent 3D, but only stores a surface normal for each pixel[12]

Project 3D and Digital Materiality

For this reason, we are trying to unify and combine the 3D surface mesh and pixel-based RTIs with their normals vectors within a new project. The surface mesh is usually generated by 3D scans or photogrammetry, and the texture is determined by RTI images. In other words, the measured values of the RTIs serve as a texture that can be merged with the 3D model. Thus it is possible to improve the visual quality and data precision because measurements of the same object are generated and combined with two completely different methods. Also important is the quality and scope of the metadata. The better the measurement processes are documented, the better the quality of the image data. A complete reproducibility of the measurements and the processes leading to the data would be the optimum. The project is planned in cooperation with the ETH Zurich and the University of Applied Science Windisch.

Within the project, cooperation with the IIIF consortium is also essential and will be of specific scope. The developments within the project should, as far as possible, go hand in hand with current and international standardisation activities.

Data Science

If this vast amount of data can be found on the web, accessed and reused, it opens up entirely new possibilities in scientific applications. Data science is necessary here, meaning data can be scientifically analysed. This evaluation ranges from simple regression to multi-dimensional analysis and visualisation. Data Science today mainly focuses on sets (larger quantities) of data objects. In the context of images, this means studying numerous resources, or in other words, distant viewing. Image data with different origins can be accessed quickly, making it possible to answer new quantitative questions in humanities research. Today researchers show how the distance to the individual (data) object reshapes the research questions [13].

In the case of enhanced imaging complexity, like 3D data, applying statistical methods to analyse correlations, differences or patterns in groups of objects is undoubtedly attractive. Methods of distant viewing in 3D information are, e.g. interesting for archaeology and other disciplines. Because of the complexity of the 3D data, precise documentation about the process is necessary. The description of the methodology must be part of the metadata.

Besides analysing large numbers of images from a distant perspective, the close-up is also becoming more potential. The amount of details that can be captured by imaging technologies and visualised on the world wide web – the most common service running on the Internet – is fascinating. Examining an object closely, without boundaries, is not only for research of interest. It also gives artefacts new attractiveness through interactivity (Fig 5).

For the evaluation of digital cultural assets, the potential of 3D representation is promising. Indeed, the image and its metadata are already precious. The possibility of data representation of 3D objects goes one step further. Through interactivity, an object can be experienced digitally. It can also be evaluated in a form that goes much further than what we can implement with normal images. The information content of a 3D model is significantly greater than that of a photograph.

Fig 4: The Statue of Hadad in the Vorderasiatisches Museum in Berlin as 3D represetation. The 3D dataset shall help to analyse the relief of the lettering in the centre part of the statue.

Conclusion

We store, archive, and make data available and usable. Digital infrastructures are becoming established, and data exchange is becoming much more accessible than just a few years ago. The form of data has also evolved: Text and images were at the beginning, audio and video have been added, and computational photography also creates new data that can be stored and evaluated. This possibility not only makes the objects themselves more visible but also the organisations that house the originals. Museums, archives and even libraries are showing great interest in new image capture techniques from computational photography. Known data analysis methods can be innovatively applied to the new datasets thus created.

The associated technological challenges are being addressed and also solved. It is, therefore, all the more critical which questions from the humanities are to be answered.

It is probably also the right time for researchers to increasingly cooperate and exchange information with GLAM institutions. The technology can be put to good and beneficial use in this way.

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