Enhanced Reflectance Transformation Imaging for Research and Interoperability

Computational Photography in Archaeology

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Introduction

A digital object representation should follow the correct use of contemporary technologies. Such digital objects create sort of a “digital layer”, overlapping the concept of a museum exhibition itself. To get the most potential out of it, we want to invite cultural heritage institutions and researchers to use computational photography to capture and archive as much information on archaeological museum objects as possible. With enhanced Reflectance Transformation Imaging (eRTI), different situations of illumination can be recreated for different purposes, be it research, publication, harvesting, interoperability and presenting digital exhibitions on websites etc.

Photographic images play a vital part in science and archeology especially in terms of documentation and communication as shown by Fornaro. Photographic reproductions allow to store the current state of objects e.g. archeologic findings for later use, and support the development of theories as well as the discussion with fellow scholars. The speed of the acquisition in a photographic process is also of importance. A photographic capture is fast, reproducible and of a high degree of authenticity. Photography is a proven and accepted medium for documentation and reproduction as Mudge (2008) showed. Photographs can be taken even if the object is of limited accessibility, e.g. because it is kept in a museum or archive or it must be captured on site while doing an excavation. Photographs document the visual appearance of objects and they are a precise tool to capture the state of an original e.g. before and after cleaning or restoration. Dissemination and accessibility are other features that have become of advantage in the digital domain. Due to these facts digital images are an important part not only for archeological research, but for our cultural heritage in general. Photographic images are considered among the best representations of originals: Photographs – in the analog and the digital domain – are drawn by light, they have a certain authenticity, are to a large extend reproducible. Photographs are therefore often used to represent an artifact and its visual appearance in presentations, documentations and exhibitions as shown by Stanco (2011).

However, a conventional photograph is static and it is impossible to reproduce the full richness of the visual impression of the object, e.g. of the granularity of the material – usually done by the help of different light situations, e.g. a directed or strong sidelight. With the advent of computer technology in imaging, new methods, have been developed to overcome the limitations of conventional photographs. Computational photography is therefore a promising approach to a more comprehensive way to capture, communicate and disseminate digital reproductions of artifacts as they can be found in archeology in general.

A promising technique that combines the positive aspects of conventional photography and the strength of computer algorithms is Reflectance Transformation Imaging (RTI) in a first experiment developed by Malzbender (2001) of HP Labs. RTI is a set of computational photographic methods that capture a subject’s surface, shape and color and enables the later interactive re-lighting of the subject from any direction based on a mathematical model. Polynomial Texture Mapping (PTM) best describes the principal technique most such approaches follow. The basic principle of PTM based RTIs is:

- A set of photographic images, each illuminated differently, is captured on site
- A program transforms the different illuminated images into a mathematical surface-model that contains the information about the object's topography, its color, shape, glossiness and materiality

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- The mathematical surface model can be re-illuminated interactively as if the object would be in an virtual photo-studio. Multiple light sources can be applied as well as candle light or illumination of a standard reproduction setup with two flashlights.

The drawback of PTMs are the limitations of the mathematical model. A second order polynomial is able to reproduce only reflection of diffuse surfaces, also called a Lambertian surface, while the realistic reproduction of gloss is not possible. Another drawback is the complexity of the full process: Various steps must be performed correctly to achieve good image result. Due to a lot of operations that need to be done by hand, reproducibility is limited. There used to be a lack of standardized capturing hardware, adequate processing software, and data formats for archiving and dissemination of such reproductions.

The application of this technology requires a lot of specific know-how that is only applicable very limited to other fields in archeologic research. Also viewing and sharing of such conventional RTIs is not as trivial as e.g. sharing web-content and viewing it in a browser application. In addition in digital reproduction techniques, standards like Metamorfoze[2] or FADGI[3] are today's state-of-the-art. The level of quality must be achieved with all modern capturing techniques as well.

Fig. 1: differently re-illuminated image of female figurines

Solution

In an interdisciplinary research project, the Team of Fornaro (2017) therefore focused on simplification of the full process from image capture to dissemination of RTIs :

- For image capture we developed a simple to use, mobile and robust light dome. The light dome is battery driven and allows to capture reproducible source images, each illuminated differently, for later processing.
- The processing software has been streamlined and integrated. It is capable to process high resolution images up to 400 MPixel[4], by a single click.

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[2]https://www.metamorfoze.nl/sites/metamorfoze.nl/files/publicatie_documenten/Metamorfoze_Preservation_Imaging_Guidelines_1.0.pdf

[3]http://www.digitizationguidelines.gov/guidelines/FADGI%20Federal%20%20Agencies%20Digital%20Guidelines%20Initiative-2016%20Final_rev1.pdf

[4] For example the Hasselblad H6D-400C captures photographs with a output size of 400 MPixel.

- Preparation of dissemination files is easy. It is possible to export web-compliant RTIs without any further knowledge.
- The software is able to simulate various types of light sources, e.g. candle light.
- Light sources can be animated, eg flickering of a candle can be visualized
- Gloss can be measured and visualized naturally.

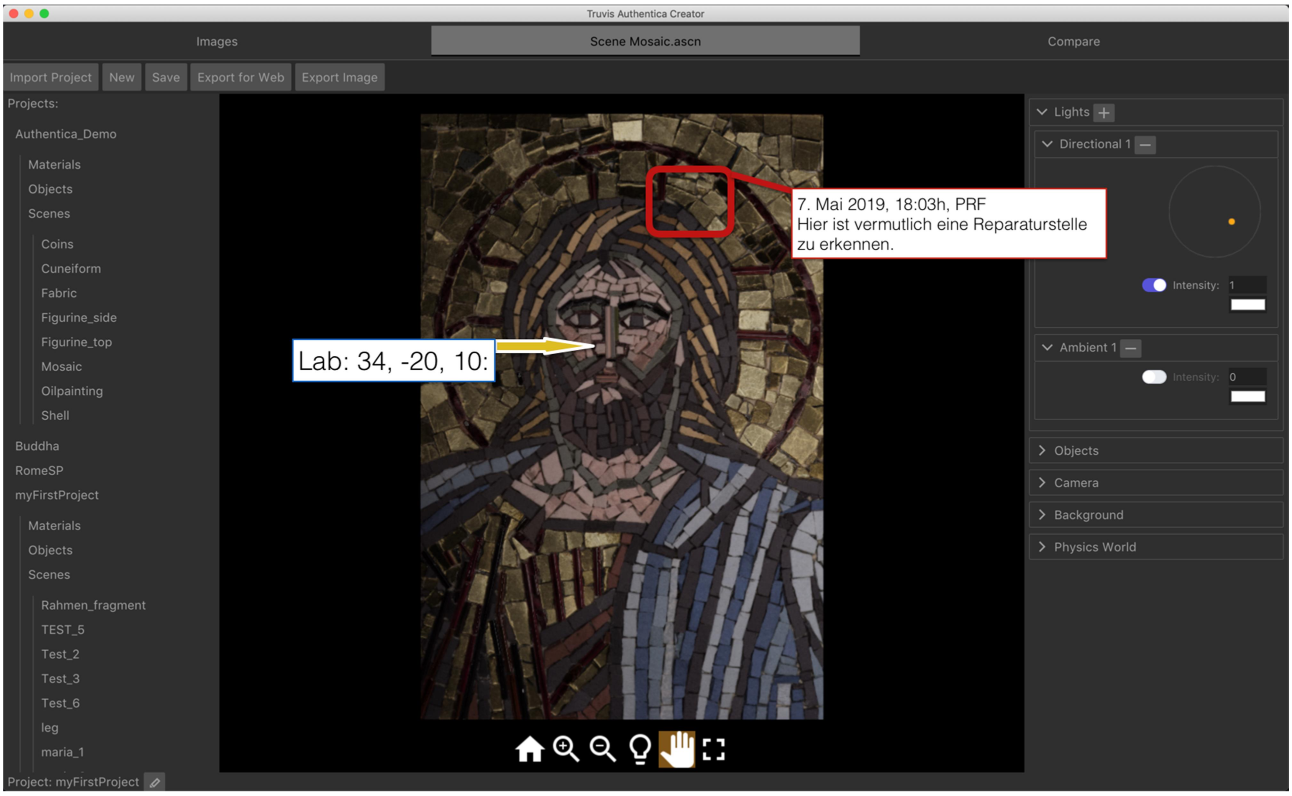
The design and implementation of the solution has been done within an interdisciplinary national research funding project of the SNSF. The aim of the project was to simulate various light reflection situations of medieval mosaics. The web-based design allows for easy integration of such enhanced RTIs in any website supporting HTML5. The solution can be operated without specific know-how and focus can be kept on the relevant aspects of the original rather than the process of capturing it.

The application of our solution on an excavation in Jordan (Petra) and at the Jordan Museum in Amman showed the strength of the system for archeological purposes. Objects could be examined after having contact with the physical material. Details could be looked at closely and comparisons could be done on screen interactively.

Outlook

The solution is now being further developed: Due to the fixed size of the light dome, the size of artefacts that can be captured is limited (objects should not be larger than 2/3 of the inner dome diameter). Therefore, stitching algorithms are designed, implemented and applied to combine multiple captures of spatially divers but overlapping RTIs.

In a second step, tools for annotation and transcription will be embedded in the software, to explain specific findings. Such tools are part of a more general database solution, that has been developed at the Digital Humanities Lab of the University of Basel and which is now the platform of the national Data and Service Centre of the Humanities, DaSCH as shown by Rosenthaler (2015). Such a digital platform allows collaborative work and it is the fundament for interoperability. Interoperability is besides open access (FAIR-Data) the fastest growing initiative and it is essential to be able to exchange and discuss image content as described here. In the case of photographic image data, there is a very promising initiative and fast-growing community that takes care of a standardized Application Programming Interface (API) to load image resources: The International Image Interoperability Framework. IIIF is a standard protocol to access image resources over the internet using the HTTP protocol. In the case of RTIs, standardization of data or access does not exist up to now, although RTIs are even more capable of exchanging relevant information about the artefact's surface between scholars. Standardized access to RTIs would mean more straightforward data exchange for efficient research.



Conclusion

In our presentation we will show the importance of modern and standardized computational photographic workflows, ranging from image capture to dissemination of such photographic image data for research for interoperability and reusability. We will demonstrate Enhanced-RTI, a state-of-the-art computational photography technology as well as adequate ways for transfer and collaborative exchange of such data.

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