Digital 3D Reconstructions as a Scholarly Area of Digital Humanities – Scholars, Projects, Implications and Perspectives

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Abstract

Since an academic discourse on using digital 3D reconstruction tools for humanities research is still highly application-oriented, an overarching objective of our research work is to draw a currently missing "big picture" on digital 3D reconstruction as a research tool in digital humanities by combining theoretically and practically grounded research parts as well as including multi-disciplinary perspectives. This article provides an overview of research work carried out by our department in 12 projects over the past seven years, namely on (a) scenarios and practices for the employment of digital 3D reconstruction and visualization methods and approaches for scientific research in visual humanities, (b) requirements and recommendations for digital tools, and (c) approaches to teach digital 3D reconstruction methods at university. The article is intended to contribute to a comprehensive discourse on a unique epistemology of digital 3D reconstruction in humanities and to deliver related practically tested implications for software design, teaching and organizational settings.

Introduction

For more than 30 years, digital 3D modelling and in particular reconstruction methods have been widely used to support research and education in the digital humanities, especially but not exclusively on historical architecture. While technological backgrounds, project opportunities, and methodological considerations for the ap-plication of digital 3D reconstruction techniques are widely discussed in literature (e.g. Arnold and Geser, 2008, European Commission, 2011, Frischer, 2008, Bentkowska-Kafel et al., 2012, Bentkowska-Kafel, 2013, Kohle, 2013), our interest is to investigate digital 3D reconstruction as a scholarly area and to derive implications for further organizational and methodical development. Against this background, this research work is dedicated to support the dissemination process by investigating the following research questions:

- What scenarios and practices exist for the employment of digital methods and approaches for scientific research within the field of digital 3D reconstruction, especially in art and architectural history?
- What are requirements and recommendations for the design of tools and media related to digital 3D re-construction?
- How can the use of digital methods and, in particular, digital 3D reconstruction techniques in visual human-ities be learned and taught?

Research

Against the background of these research interests, our research activities include to investigate (1) a scholarly community, (2) usage practices occurring with-in single projects and to gain implications for an appropriate organizational development. Moreover, practical application and a development of implications for (4) the conception and creation of a user-centered design of software tools and environments for digital humanities scholars and an (5) implementation in student education are in focus. Research methods and approaches used within the described research activity mainly derive from social and information sciences as well as from science and technology studies (cf. Hackett et al., 2008, Boczkowski and Lievrouw, 2008, pp. 955) and comprise e.g. bibliometric analysis (cf. Vinkler, 1996), quantitative and qualitative empirical analysis as well as structuring approaches like mind mapping (Table 1). Relevant research has been active since 2010 in 12 projects (ongoing till approx. 2020) on the local, national and EU levels, with our department's participation.

Research part	Purpose	Approach (exemplified reference)
Knowledge base	Information structuring	Wiki (c.f. e.g. Wiki Education Foundation, n.a.)
		Mind mapping (c.f. e.g. ThinkBuzan Ltd.)
Scientific structures	Author cohorts	Key numbers (c.f. e.g. De Solla Price, 1963)
		Clustering of authors (c.f. e.g. Moed et al., 2006)
	Structures	Social Network Analysis (c.f. e.g. Wellman, 1988)
	Topic mining	NLP (c.f. e.g. Anaya, 2011)
Usage practices	Data collection	Case studies (c.f. e.g. Yin, 2003)
		Expert Interviews (c.f. e.g. Gläser and Laudel, 2009)
		Observation (c.f. e.g. Lamnek, 2005)
		Heuristic Frameworks (c.f. e.g. Kubicek, 1977)
	Data analysis	Grounded Theory (c.f. e.g. Bryant and Charmaz, 2010)
		Qualitative Content Analysis (c.f. e.g. Mayring, 2000)
Systematization	Expert opinion	Literature Review (c.f. e.g. Cooper and Hedges, 2009)
		Group discussion (c.f. e.g. Lamnek, 2005)
Design	User Experience	Usability Engineering (c.f. e.g. Nielsen, 1993)
	Testing	Questionnaires (c.f. e.g. Barnum, 2011)
		User observation (c.f. e.g. Tullis and Albert, 2008)
Education	Educational design	Project-based learning (c.f. e.g. Donelly and Fitzmaurice, 2005)
	Assessment	Formative & summative (c.f. e.g. Dumit, 2012)

Table 1. Brief overview of methodical approaches

Results

Considering a scholarly community on digital 3D reconstruction and modeling, discourses on major conferences during the last 25 years were mainly led by institutions from European Mediterranean countries, covering primarily technological topics. In particular, statues and buildings in Mediterranean countries dating from all periods Anno Domini deliver rich content for such reconstruction (Fig. 1). Institutions with high numbers of publications, connections to co-authors or the extraordinary importance to link groups of researchers to each other can be identified on a structural level (cf. Fig. 2). Due to the high complexity and team based workflows, aspects and usage practices for communication, cooperation, and quality management are of high relevance within 3D reconstruction projects. Especially if people with different disciplinary backgrounds are involved, visual media are intensively used to foster communication and quality negotiations (cf. Fig. 3), for example by comparing source images and renderings of the created virtual reconstruction. Furthermore, several projects successfully adopted highly standardized conventions from architectural drawings for interdisciplinary exchange (Münster, 2013). To support an organizational development, we ran five workshops to identify ongoing research topics and challenges, involving around 100 researchers in total. Current challenges named (cf. Fig. 4) aim at a research and development of sustainable and practicable approaches to access wider scientific communities and audiences and include aspects such as widely interoperable documentation and classification strategies and schemes, an overarching cataloguing of projects, and the creation of objects as well as strategies and technologies for an exchange

between different technological domains and approaches of usage. Regarding design implications for digital environments, we investigated, for example, that relatively little visual information is needed to allow observers to distinguish buildings from each other or to identify a single building and gain information about its spatial relation and shape (Münster et al., 2017b). Moreover, we adopted and evaluated team project-based learning approaches to support student education in digital 3D reconstruction (cf. Fig. 6). As observed in two courses so far, a development of procedures and strategies for cooperation within student project teams for creating virtual representations evolves slowly and is mostly caused by emerging problems and urgent demands. Related competencies are based highly on implicit knowledge and experience. As a consequence, a teaching of implications and best practices prior to commencing a project is less effective than coaching during the project work.
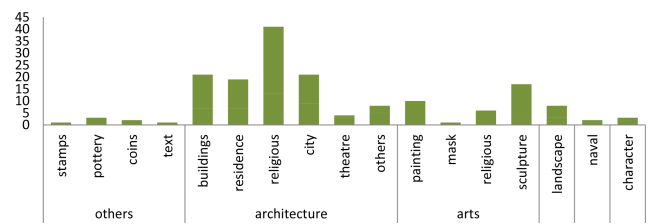

Figure 1. Types of 3D reconstructed and modelled artifacts (Sample: 478 publications on digital 3D modeling in humanities)
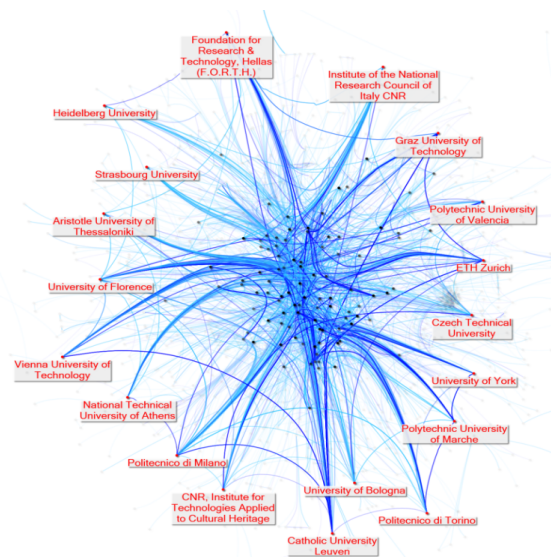

Figure 2. Accumulated Author-Co-Author Relations by institutions (TOP 10 in Degree, Count, Betweenness

Centrality named, Sample: 3917 publications on digital 3D modeling in humanities)
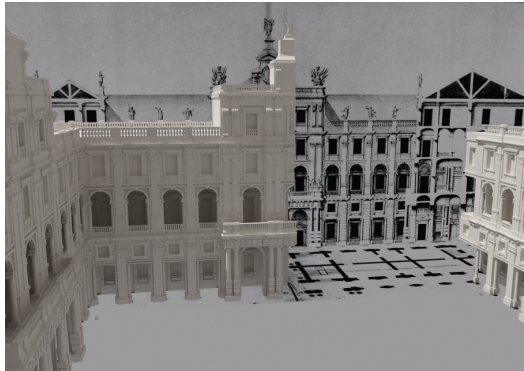

Figure 3. Exemplified modeling as well as quality control techniques. Originally published in (Münster et al., 2017a).

"assessment of practice-oriented aspects beyond questions of humanities like learning, usability or sustainable business models"

"capacity of making a model logic transparent"

"3D data viewers"

"tools and mechanisms for semantic annotation and modification of extant reconstructions"

"documentation of processes and their results"

"tools for versioning"

"suitable workflows and strategies used for the creation of digital reconstructions"

"transfer and exchange between research and practical use"

"development of knowledge and competencies"

"technologies and strategies on data interoperability"

"mapping of digital reconstruction projects"

Figure 4. (Selected) future challenges named for digital 3D reconstruction in academic contexts (outcome from a workshop series involving around 60 international researchers).

Figure 5. Results from Freiberg Cathedral App educational project. Models: Wachsmuth et al., 2014

Summary

Since it is our vision to establish digital 3D reconstruction as a scholarly accepted and widely used research method in humanities, it seems to be crucial to add a critically reflected methodological basis and anchor it in academic culture. To draw this currently missing "big picture", our department performed research on digital 3D reconstruction within various projects by combining both theoretically and practically grounded research parts. This comprises research on scholarly communities, scholarly practices and methodological recommendations as well as implications for interaction design, teaching and dissemination.

Bibliography

Anaya, L. H. (2011). *Comparing Latent Dirichlet Allocation And Latent Semantic Analysis As Classifiers,* Denton, University Of North Texas.

Arnold, D. & Geser, G. (2008). *Epoch Research Agenda – Final Report*, Brighton.

Barnum, C. M. (2011). *Usability Testing Essentials : Ready, Set...Test!,* Burlington, Morgan Kaufmann.

Bentkowska-Kafel, A. (2013). *Mapping Digital Art History*, Los Angeles, Getty Conservation.

Bentkowska-Kafel, A., Denard, H. & Baker, D. (2012). *Paradata And Transparency In Virtual Heritage,* Burlington, Ashgate.

Boczkowski, P. & Lievrouw, L. A. (2008). Bridging Sts And Communication Studies. In: Hackett, E. J., Amsterdamska, O., Lynch, M. & Wajcman, J. (Eds.) *The Handbook Of Science And Technology Studies.* 3rd Ed. Ed. Cambridge: Mit Press.

Bryant, A. & Charmaz, K. (2010). *The Sage Handbook Of Grounded Theory,* Thousand Oaks, Sage.

Cooper, H. & Hedges, L. V. (2009). *The Handbook Of Research Synthesis And Meta-Analysis*, New York, Russell Sage Foundation.

De Solla Price, D. (1963). *Little Science - Big Science,* New York, Columbia Univ. Press.

Donelly, R. & Fitzmaurice, M. (2005). Collaborative Project-Based Learning And Problem-Based Learning In Higher Education: A Consideration Of Tutor And Student Role In Learner-Focused Strategies. In: O'neill, G., Moore, S. & Mcmullin, B. (Eds.) *Emerging Issues In The Practice Of University Learning And Teaching. Dublin: All Ireland Society For Higher Education* (Aishe).

Dumit, N. Y. (2012). Diagnostic/Formative/Summative Assessment, N.N.

European Commission (2011). Survey And Outcomes Of Cultural Heritage Research Projects Supported In *The Context Of Eu Environmental Research Programmes. From 5th To 7th Framework Programme,* Brussels, European Commision.

Frischer, B. (2008). Beyond Illustration : 2d And 3d Digital Technologies As Tools For Discovery In Archaeology, Oxford, Tempus Reparatum.

Gläser, J. & Laudel, G. (2009). *Experteninterviews Und Qualitative Inhaltsanalyse Als Instrumente Rekonstruierender Untersuchungen*, Wiesbaden, Vs Verlag Für Sozialwissenschaften.

Hackett, E. J., Amsterdamska, O., Lynch, M. & Wajcman, J. (2008). The Handbook Of Science And Technology Studies, Cambridge, Mit Press.

Kohle, H. (2013). *Digitale Bildwissenschaft,* Glückstadt.

Kubicek, H. (1977). Heuristische Bezugsrahmen Und Heuristisch Angelegte Forschungsdesigns Als Element Einer Konstruktionsstrategie Empirischer Forschung. In: Köhler, R. (Ed.) *Empirische Und Handlungstheoretische Forschungskonzeptionen In Der Betriebswirtschaftslehre*. Stuttgart.

Lamnek, S. (2005). Qualitative Sozialforschung. Lehrbuch, Weinheim.

Mayring, P. (2000). Qualitative Content Analysis. Forum Qualitative Sozialforschung, 1, Art. 20.

Moed, H. F., Glänzel, W. & Schmoch, U. (2006). *Handbook Of Quantitative Science And Technology Research: The Use Of Publication And Patent Statistics In Studies Of S&T Systems,* Springer Science & Business Media.

Münster, S. (2013). Workflows And The Role Of Images For A Virtual 3d Reconstruction Of No Longer Extant Historic Objects. Ann. Photogramm. *Remote Sens. Spatial Inf. Sci.*, Ii-5/W1 (Xxiv International Cipa Symposium), 197–202.

Münster, S., Jahn, P.-H. & Wacker, M. (2017a.) Von Plan- Und Bildquellen Zum Virtuellen Gebäudemodell. Zur Bedeutung Der Bildlichkeit Für Die Digitale 3d-Rekonstruktion Historischer Architektur. In: Ammon, S. & Hinterwaldner, I. (Eds.) *Bildlichkeit Im Zeitalter Der Modellierung. Operative Artefakte In Entwurfsprozessen Der Architektur Und Des Ingenieurwesens*. München: Wilhelm Fink Verlag.

Münster, S., Kröber, C., Weller, H. & Prechtel, N. (2017b). Virtual Reconstructions Of Historical Architecture As Media For Visual Knowledge Representation. In: Ioannides, M., Magnenat-Thalmann, N. & Papagiannakis, G. (Eds.) *Mixed Reality And Gamification For Cultural Heritage.* Cham: Springer Lncs.

Nielsen, J. (1993). *Usability Engineering,* Salt Lake City, Academic Press.

Thinkbuzan Ltd. (n.d.) Mind Mapping: Scientific Research And Studies.

Tullis, T. & Albert, B. (2008). *Measuring The User Experience,* Amsterdam, Mrgan Kaufman Publishers.

Vinkler, P. (1996). Some Practical Aspects Of The Standardization Of Scientometric Indicators. *Scientometrics*, 35, 237-245.

Wellman, B. (1988). Structural Analysis. From Method And Metaphor To Theory And Substance. In: Wellman, B. & Berkowitz, S. D. (Eds.) *Social Structures: A Network Approach.* Princeton: Princeton University Press.

Wiki Education Foundation (n.d.) *N.A. Theories: Wikipedia And The Production Of Knowledge.*

Yin, R. K. (2003). *Applications Of Case Study Research,* Thousand Oaks, Sage.