Virtual museums as an extended museum experience: Challenges and impacts for museology, digital humanities, museums and visitors – in times of (Coronavirus) crisis

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Abstract

Since there has been a recent trend to establishing virtual museums, which various institutions have swiftly responded to, the objective of this paper is to understand the nature of virtual and/or digital museums by focusing on their particular characteristics. In this approach, the paper proceeds from the assumption that museum representations in the virtual space and/or virtual museums could extend conventional or physical museum space, leading to enhanced visitor attraction and experience. The paper thus focuses on the virtual museum as an interdisciplinary and transdisciplinary object of investigation from the perspective of museology and digital humanities and seeks to ascertain whether scholarly and practical impacts are achieved. It also analyses the expected impacts on practical museum work and visitor needs, especially with respect to the tasks museums are required to fulfil in times of crisis.

Introduction

The increased importance attached to virtual museums has transformed them into a major object of investigation, both in practice and in theory. In this context, this methodological and theory-driven paper asks whether and how digital and/or virtual museums could extend conventional and prevalent physical museum spaces. The paper argues that a virtual museum could serve as an interdisciplinary and transdisciplinary object of investigation[1], making special reference to the scholarly background of the disciplines of museology and digital humanities and investigating the specific characteristics of virtual museums.

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Against this backdrop, the paper proposes that the digital virtual museum could extend conventional museum space by providing enhanced visitor experiences in terms of engagement and attraction. It investigates the manifold scholarly and practical impacts of extending the physical museum space into the virtual world from the theoretical perspectives of museology and digital humanities, as well as with respect to practical approaches that are necessary for museums and their visitors and users. In that context, the paper also relates to the relevance of virtual museums for museums and their visitors, especially in times of crisis, hence, particularly in times when those museums have to close their collections and exhibitions for various reasons, for example, in the current pandemic situation.

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At least in the German speaking world, the term "virtual museum" has been subject of discussion since the 1990s, but is still awaiting a clear definition (see Schweibenz [2016]; Biedermann [2017a]; and Niewerth [2020]).[2] Recently, German speaking regions call for a "digital museum," while the Anglophone world has argued in favour of a "virtual museum," where both parties define a virtual museum as a digital entity. This digital entity summarises digital reproductions of museum objects[3] respectively, drawing on "the characteristics of a museum, in order to complement, enhance, or augment the museum through personalization, interactivity, user experience and richness of content"[4].

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To answer the research question as to how digital or virtual museums should extend conventional museum space as an interdisciplinary and transdisciplinary object of investigation, the paper first focuses on the characteristics of recent

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digital or virtual museums, in order to find out how they engage with and attract museum visitors compared with physical museum space. In this context, the focus lies on the differences between, and similarities of, conventional and virtual museum spaces and refers to state-of-the-art museology and museum studies and digital humanities respectively.

Secondly, taking the previously mentioned into consideration, the paper sets out to achieve an understanding of a virtual museum and its characteristics against the backdrop of the responsible disciplines concerned with that field, especially from the perspective of general museology [Waidacher 1999a] [Desvallées and Mairesse 2010]. General museology differs from other object-centred disciplines of the humanities as well as from the approach taken by museum studies in the way it defines its object of knowledge. Museology defines this as a special relationship of man to his environment, leading to the selection, preservation, interpretation and exhibition of meaningful objects. This relationship is also referred to as museality (see Stránský [1971a]; and Biedermann [2017b]). From the perspective of 'general museology', museality is a supratemporal quality expressed differently in various times, its recent expression being the conventional or physical museum space of the institutional museum displaying museum objects physically to engage visitors.

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Consequently, the paper presents perspectives in order to achieve an understanding of the virtual museum as extended museum space from the perspective of digital humanities [Jannidis et al. 2017] [Kurz 2015] [Terras et al. 2013], exploring strategies to digitally augment physical museum space. In this context, the paper draws on the approach taken by the University of Graz. Both disciplines are concerned with the topic of a virtual museum and, in that context, subsequently define the virtual museum as an interdisciplinary and transdisciplinary object of investigation with respect to the fundamental theoretical and practical aspects concerned.

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On this basis, I also address the challenges of establishing a virtual museum, or museum (re)presentations in virtual space, as interdisciplinary and transdisciplinary objects of investigation, and I consider practical approaches to establishing a virtual museum.

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Finally, the paper expounds on the relevant impacts of virtual museums with regard to the underlying research question as to how digital virtual museums could extend conventional and prevalent physical museum space. Impacts also include practical aspects of museum work as well as those relating to visitors and users. All these impacts are key to addressing new target groups, along with the crucial aspect that virtual museums can provide access to museum collections and their communication strategies even in times when museums have to close their doors to the public, for example, during the current Coronavirus crisis, which is just one of several possible scenarios.

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In its conclusion, the paper subsumes the relevant research desiderata in the field, especially in terms of establishing a virtual museum as an interdisciplinary and transdisciplinary field of application for the disciplines of general museology and digital humanities, finally also presenting a vision of what a virtual museum (considering the theoretical aspects in question) could look like.

9

Characterising a virtual museum

At least in German speaking regions, the term "virtual museum" has been controversially discussed since the 1990s [Schweibenz 2016] [Biedermann 2017a] [Niewerth 2020], thus challenging the well-established museum definition proposed by the International Council of Museums (ICOM)[5]. The ICOM's museum definition refers to physical museums' objects as being selected, preserved, interpreted and exhibited. Concerning virtual museums, sceptics have argued for physical museum space and physical engagement with the real object, which cannot be virtualised and thus substituted by a digital one, just as virtual restaurants cannot serve a real meal. From that perspective, virtualising physical museum space would also mean virtualising the actual creative and physical encounter between people of the present and authentic witnesses of the past. This assumption posits that the museum visitor's encounter with the physical world cannot be transposed to the virtual world. That is the reason why "virtual museum" was interpreted as an oxymoron term.

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Finally, a methodological expedient defines representations of museum collections in virtual space and the originating "e-tangibles" (see Parry [2007] 68) as additional forms of museum communication that neither substitute nor compete with the real and physical museum, but rather address various other communication needs of visitors (see Biedermann

11

[2017a]).

While German-speaking regions call for a "digital museum," the Anglophone world argues in favour of the term "virtual museum." However, both define it as a digital entity which summarises digital reproductions of museum objects (see Wikipedia)[6] and "draws on the characteristics of a museum, in order to complement, enhance, or augment the museum through personalization, interactivity, user experience and richness of content"[7].

Recent digital entities that summarise digital reproductions of museum objects[8] appear specifically as museum online databases or web portals. Consequently, many museums are digitising, or have already digitised their collections systematically, and their visitors have access to considerably more museum objects via the world wide web than was the case only a few years ago. Basically, they draw on museum collections and museum object data digitally enriched and represented in various forms in the virtual space. They appear as museum databases providing open access to museum object data and digital images of museum objects, as well as digital online exhibitions focusing on various topics.[9] Additionally, various web portals serve as open access meta-databases (see web portal Europeana[10]; web portal Deutsche digitale Bibliothek[11]). In that context, semantic web technologies and digital museum standards are significant for museums (see LIDO[12] and CIDOC-CRM[13]). Standards for museum vocabularies are in progress (museumvok;[14] Getty Arts & Architecture Thesaurus[15]). Moreover, museum websites, newsletters, social media outlets, and digital forms of museum communication now reflect a rather modified perspective and method in the visitor's perception and therefore extend conventional museum space to encompass modified space.

Additionally, digital museum features enhance conventional museum space by means of augmented and virtual reality. Augmented reality can present "some of the untold stories behind one of the museum's most iconic collections" [Costello 2019], by giving insight into hidden paint layers [Topcu 2019] or how animals could have seen the basis of their "skin and bones" (National Museum of Natural History, Smithsonian Institution).[16] Augmented reality can also bring specimens to life [Costello 2019]. Conversely, virtual museum space also integrates tools to augment museal reality, whereby virtual museums, galleries and cultural heritage tours can all complement, enhance and augment conventional museum space, especially through interactivity and user experience.[17]

Moreover, 3D techniques expand the field of digital museum features in virtual space by 3D scanning of objects. These scans create virtual copies of museum objects that serve the purpose of digitally turning the object or zooming in, which is not possible in the case of original museum objects. 3D prints of these objects enhance the user experience in physical museum space, because of the possibility to touch and handle them. Virtual museum space also provides online access to 3D copies of museum objects[18] and to 3D tours of conventional museum space. This is why applied 3D techniques also broadly augment conventional museum space by immersive methods and provide a virtual reality to enable manifold possibilities of interactive visitor engagement (see Carrozzino and Bergamasco [2010]).

Virtualising museums from the perspective of museology

Prevalent conventional physical museums operate in the interest of classical museology and its object of investigation, which is known as museality [Waidacher 1999a] [Stránský 1971a, 14–39] [Stránský1971b, 40–66] [Desvallées and Mairesse 2010, 53–66]. Museality is a "relation between man and his reality by which he realises and decides in accordance with society which parts of the surrounding natural and arranged world are able to act as witnesses to this reality and are thus worthy to be systematised, researched, mediated and traded as bearers of this relation" [Waidacher 1999a, 723].[19] Currently, the conventional museum still dominates scientific discourse relating to museum documentation and presentation.

According to the theory of museality, to give just one example, the vehicle in which heir to the Austro-Hungarian throne Archduke Franz Ferdinand and his wife Sophie were assassinated on 28th June 1914, is an authentic witness of this event. It is a "Gräf & Stift Double Phaeton" car, which is currently on display at the Museum of Military History in Vienna (Heeresgeschichtliches Museum Vienna). That vehicle bears witness to the event that triggered the outbreak of the First World War; it has a special function as an object of memory concerning the persons involved – especially the murdered

heir to the throne and his wife. At the same time, the object is emblematic – it symbolises the outbreak of WWI. Hence, it serves as a bearer of museality and possesses effective legitimacy to act as a museum object. Needless to say, this artefact could transport many more stories than the one mentioned above (see also Heeresgeschichtliches Museum Vienna).[20] Nevertheless, the intrinsic aim, goal and purpose of any conventional museum space – as the display showing the Archduke's vehicle exemplifies – is the actual creative encounter between a present-day person and an authentic object of history.

Nonetheless, from the perspective of museology it is a central and defining point that museum objects can serve as authentic witnesses of an event or a process. Moreover, they relate to persons, dates and places, and therefore, the object is an item of evidence for something or somebody. A scientific and hermeneutical process verifies this evidence and defines an object as bearer of museality. At the same time, this object becomes a "nouophor" – a bearer of sense and meaning [Waidacher 1997, 20]. The unique aspect of the concept museality lies in its time independence, which means that it appears independent of time by changing forms of its expression. Consequently, it deserves a mirror of historical circumstances. At the same time, museality determines the object of interest as part of the discipline museology and defines museology as belonging to the humanities (see Biedermann [2017b]). | 18

Museology focuses on objects as sources and acts from a meta-perspective in terms of other object-centred disciplines of the humanities (such as art history, ethnology or archaeology) and natural sciences (such as geology, zoology, physics and so on). The objects thus act as evidence for various events and are especially significant – both with regard to their materiality [Pearce 1992, 1–10] [Buchli 2002] and symbolic meaning [Pearce 1992] [Marstine 2006, 1–36] [Carbonell 2012]. As a result, objects are able to tell numerous stories depending on the focus of the display and the storytelling. | 19

Both the approaches of museology and museum studies focus on questions of digitising and virtualising forms of museum communication (see Parry [2010]; Hoptman [1994]; Langner [2015]; Navarrete and Owen [2016]; Whitelaw [2015]). In that context, they reflect the claim to authenticity of conventional museum spaces (see Parry [2007]). | 20

However, amongst other examples, the digital presentation of the Archduke's vehicle shows that forms of digital presentations are generally becoming more important for conventional museums, which have been enlarging their digitisation and virtualisation programmes for many years. | 21

Virtualising museums from the perspective of the digital humanities

Particularly in German speaking regions, research in the field of digital humanities focuses on the information content of humanistic sources and primarily on modelling that content. Basically, this means describing and managing as well as visualising (meta)data by means of information transformation and exchange for the purpose of information intercommunication (see Arthur and Bode [2014]; Büttcher, Clarke and La Cormack [2016]; Cartner [2013]; Jannidis, Kohle and Rehbein [2017]; Kurz [2015]; Schreibmann and Siemens [2016]; Terras, Nyhan and Vanhoutte [2013]). | 22

Hence, in the German language-related context outlined above, the field of digital humanities is also beginning to highlight the museum as object of investigation (see Rehbein and Kunze [2019]) with a focus on digitising, enriching, standardising, formalising and contextualising museum object data. Moreover, digital humanities are supporting the discipline of museum presentation by using visualising techniques and offering open access to relevant data, which broadens the field to address new research questions. | 23

This approach applies digital standards of museum object documentation such as LIDO, which is compliant to the CIDOC-CRM.[21] The University of Graz's approach in this area is to transform and to visualise the data in the university's asset management system, named GAMS[22]. | 24

Against this backdrop, digital humanities' projects have recently developed "virtual museums" which show special "rooms."[23] Various other institutions have realised projects related to virtual museums, such as using the example of dictionaries.[24] Currently, several research focuses pursued by various universities are on objects and cultural heritage. | 25

[25] Other projects focus on the digitisation of cultural heritage (project Zafar)[26] and 3D reconstructions using virtual research infrastructures (for example, using castles in Prussia).[27] The digital humanities systematise various interpretations of 3D copies, and reconstructions are also a matter of interest (see Münster [2016]). In this context, the technique of photogrammetry plays an important role in 3D scanning and copying museum objects. The University of Graz, which plays no small role in those pioneering achievements, has designed an online platform as a "virtual museum" for its digitised object collections on GAMS – an asset management system for the humanities (GAMS virtual museum;[28] Stigler and Steiner [2017]). In that way, the object of study of digital humanities is gradually extending from text sources to cultural heritage and historical objects within the interior and exterior museum space (see Reisinger [2013]; see also the project DiTAH).[29]

26　The University of Graz's approach in the context of digital humanities is based on semantic annotation, processing for tagging and analysing texts realised by special, almost XML-based standards (such as TEI – Text Encoding Initiative),[30] as well as visualising structured content by means of serialisations (such as XML, RDFa or JSON-LD).[31] In this approach, controlled vocabularies use knowledge systems to structure information, and subsequently to exchange data (for example, RDF, SKOS and OWL).[32] These technologies enrich the semantic web as "open linked data" (see Berners-Lee [2006]). Annotated and structured data therefore provide the basis to generate new research questions. The structured data is then transformed (supported by XSLT)[33] and thus prepared for presentation (supported by XSLT-FO;[34] see Institut für Dokumentologie und Editorik;[35] see Sahle [2013]). In that way, special aspects of combined data[36] can be addressed[37] to make them generally and easily accessible (see Perstling [2013]; Thaller [2013]; Vogeler [2005]).

27　Digital humanities are also seeking for solutions to facilitate long-term archiving (see Thaller [2013]) and long-lasting access to cultural heritage data in form of digital research infrastructures (see GAMS[38], WissKI[39] and the project "Objekte im Netz").[40]

28　More recently, digital humanities have started to focus not only on 3D techniques like photogrammetry and 3D scanning of museum objects and cultural heritage sites, but on augmented reality as well. The project titled "Virtual Museum of the Archaeological Collection" at the University of Graz is an example of this. As part of this project, both the objects and historical exhibition space are documented with the aid of 3D techniques ("virtual museum of the archaeological collection"[41]).

Virtual Museums as an interdisciplinary and transdisciplinary object of investigation and extended museum space

29　Virtualising physical museum space has effects on conventional museums, especially in terms of their presentation and communication strategies. The focus of museum communication always lies on the audience as a major subject of interest, as well as on digital forms of museum communication. At the same time, those digital processes and projects mentioned above are in the process of modifying conventional museum space and transferring communication strategies to the digital and/or virtual world as a kind of "public museum ecosystem" [Hartig 2019]. Neither the conventional museum space nor its modified counterpart correspond to virtual space, as they generate two different kinds of perception. Consequently, the experience of physical space in conventional museums, which a virtual museum obviously lacks, needs to be configured to serve as an extended museum experience in virtual space – and vice versa.

30　As a consequence, the virtual museum requires extended methods based on the theory of classical museology and on digital humanities to define tasks for and impacts of museums in the virtual space. From a scientific point of view, these "new" challenges give rise to an interdisciplinary field in the discourse between the poles of museology and digital humanities and information technologies respectively. The question of characteristics and criteria of virtual museums are thus becoming a mutually transdisciplinary object of investigation within current discourse, which needs to be viewed against the backdrop of current projects and with regard to state-of-the-art virtual museums.

While debating on a virtual museum within an interdisciplinary and transdisciplinary discourse between the poles of digital humanities and museology, it is vital to understand the particular characteristics of museum objects, as opposed to texts. From a museological perspective, texts are documents of the mind and especially determined by the content of information they transfer [Waidacher 1999b, 5]. By contrast, a museum object is a singular man-made artefact or a selected natural object, a semiophor, or bearer of symbols (see Pomian [1988]), and more explicitly – as already mentioned – as a nouophor [Waidacher 1998], or bearer of sense and meaning. The value of a museum object is thus inextricably linked to its context information and its special object history. Hence, it is determined by the extent of its documented 'object biography'. Museum documentation thereby defines an object, not only in terms of its materiality – by way of primary documentation (see Waidacher [1999b]), but also in terms of being a material witness concerning special events or circumstances – by way of secondary documentation [Waidacher 1999b], which also refers to the immaterial aspects of museum objects to be documented.

In this context, the question arises of how to characterise a virtual museum and how to define its appearance from an interdisciplinary point of view. The interdisciplinary challenge is therefore to bridge the gap between real and virtual museum spaces, but not by substituting one for the other through simulation, comparable with Plato's allegory of the cave. Conversely, a video call suffices to interconnect and transfer information but is not able to substitute a physical encounter – as aptly demonstrated and emotively experienced during the ongoing recent Coronavirus crisis. After all, a photograph or hologram is not a physically present person, but merely a (virtual) representation of that person. The challenges concerning authenticity and space are obviously central to this discourse.

In that sense, several research questions arise from the perspective of digital humanities. The challenges to be faced in this regard concern the extension of conventional museum space into virtual space by enabling an enhanced visitor experience. This enhanced experience is created by communicating the specialities of the institution museum, which is grounded in the museum object as a bearer of sense and meaning and as an expression of museality. This is precisely why the basic objective of virtualising physical museum space is to communicate museum objects, (hidden) (hi)stories and contexts by using methods and tools of digital humanities in a way that conventional museums are not able to.

As a consequence, the challenges of digital humanities regarding a virtual museum first of all face the processes of modelling the object metadata for presentation and visualisation in physical as well as virtual spaces. From the perspective of museology, these challenges refer to the circulation of museum objects within the process of documenting or collecting metadata. This process corresponds to registering, making an inventory and cataloguing the items as well as collecting data relating to the entire object history in the context of 'biography', including the immaterial aspects of the museum object. From the perspective of applied museology, these processes are operated by a museum management system, for example, a database. As regards digital methods, this means information modelling, describing, standardising and formalising metadata, as well as managing and ordering knowledge.

Collecting the basic data of museum objects – from a museological perspective, the so-called primary documentation – means to register data that refers to the materiality of the object, such as its material, form, technique, measurements and so on. Primary documentation also means gathering information in terms of primary events to which the object is linked, such as producers, developers, artists and users as historic subjects. Museum curators, exhibit designers and museum staff act as a "museum's instance" which corresponds in most classic museum spaces to the museum's interpretational sovereignty from a scientific point of view. In a further step, all of the gathered data is modelled and describes the objects and the object data as metadata. All in all, digital methods are used to manage and order knowledge.

Museum documentation also collects data relating to dates and place names of objects. To again cite the example of Franz-Ferdinand's motorcar, the 28th June 1914 is a relevant date that is primarily associated with this object. However, it is also related to the 15th December 1919, the date on which the owner of the object, Count Harrach, a friend of the Imperial Family, donated this vehicle to the heir to the throne.

In the context of structuring object data in a logical order, various challenges concerning the standardisation of data can arise. Art historians often use the term "indeed" or "probably" to express the time 'around 1900' to which an object is

related. However, this classification is unreadable for machines because they need relatively accurate dates to process the data. To render date-related data machine-readable, and thus traceable, using search engines, the curators have to define concrete dates according to documentation guidelines, for example instead of "indeed around 1900" they use 1895 as the earliest and 1905 as the latest date of production. Specifying information, of course, goes hand in hand with the hermeneutical process of researching object biographies. Consequently, such documentation guidelines should be used for an entire collection and virtual museum respectively.

The secondary documentation process collects data describing the object as a bearer of sense and meaning, as a nouophor and an expression of museality. This results from the hermeneutic process of investigating an object as an expression of museality and describes the object from a synchronic as well as a diachronic perspective. Consequently, an object can have associations, for instance, to birth, baptism, marriage, death or – like the vehicle described – to assassination and war. In addition, the vehicle plays an important role in the discourse of memory culture as well as in the context of the recent commemoration of the outbreak and end of World War I and their anniversaries (1914/18-2014/18).

Furthermore, objects have relations to museum-related administrative workflows such as loans, conservation activities and displays, which is primarily relevant to collection management. These basic and deepened object data, which are the results of primary and secondary documentation, build the foundation for visualisations in virtual space (for example managed by digital transformations, like XSLT[42]).

The first step in collecting data is managed by surfaces of databases or repositories, or in the case of smaller museums or projects, by Excel spreadsheets or word templates. These templates are mapped to already existing XML-based museum documentation standards like LIDO or also to TEI by using transformations and with the help of special programmes and (open source) software (see Oxygen[43] and Oxgarage[44]). In terms of museum data, the digital humanities use the data harvesting standard LIDO[45] which is compliant to the CIDOC-CRM,[46] an ontology to describe museum objects referenced by events and properties. The digital research infrastructure WissKI is based on CIDOC-CRM ontology.[47]WissKI is built as a graph database to manage primary research data and for special use in museum management systems.

Museum objects are especially relevant in terms of their meaning and the events and persons they bear witness to. Consequently, there are unlimited options of relations between objects and events, persons, times and places, just as in the case of categories which describe these object relations. This means enhancing controlled vocabulary by using museological criteria, which particularly requires the establishment of museological thesauri. Such thesauri form structured concepts of object meaning in systems of controlled vocabulary. The XML standard SKOS is one possible and useful digital standard (see SKOS)[48] to map controlled vocabulary. SKOS categorises each concept by means of an identifier, which references the concept of the thesauri and contributes to representing the object meaning. By integrating these concepts into semantic web technologies (referring to SKOS), data is also accessible as "linked open data," thereby enriching the semantic web.

Different categories of sources, like index cards and images can reveal the history or the biography of museum objects. They show the provenance of objects and parts of the stories stored in objects. Digital collection complexes in virtual space enable all this information to interlink and link to the object in a structured manner. In this way, visitors can enjoy a multi-perspective view of the unique object. This also applies to the "open GLAM initiative" (see Open GLAM)[49] and to the claim of open access to memory-related institutional data, in particular with regard to galleries, libraries, archives and museums.

Requirements for digital humanities not only apply to the workflow of museum documentation, but also to the presentation method. To exemplify the University of Graz's digital humanities approach, transformations of modelled data form the basis for data visualisations realised by XSLT-stylesheets, which support data output in various forms and formats (like PDF, XHTML, SVG, SMIL)[50] also at least printed on paper. These transformations map collected data on webpages, for example, and in terms of databases, interfaces are provided to support web presentations. These

presentations map object biographies by linking objects to their metadata, to images and additional context information, and provide multi-perspective access to view the items. In this way, it is possible to create undreamt-of links to objects and collections which are not displayed or displayable, or which are dislocated, taking account of their very specific relations.

In contrast to the medium text, which, from the perspective of digital humanities, often requires the separation of form and content [Sahle 2013], the museum object calls for concentration on the single authentic object in combination with its metadata to which the object is intrinsically linked. As regards virtual museums, the aspect of museum documentation or data gathering is of special importance due to the need to build a basis for all other virtual communication strategies of digital storytelling, 3D techniques and augmented reality. On the basis of museum documentation, the object requires special tools to manage story-telling in order to offer narratives. Virtual space enables objects to be brought together, which for various museological reasons cannot be displayed (together) in conventional museum space. In addition, virtual museum presentations provide narrative access to objects on virtual guided tours, also giving narrative approaches to museum objects by linking object data, images and various groups of objects. The digital humanities, and in this context, informatics, thus also develop tools for the presentation of virtual guided tours (see: e.g. StoryMapJS).[51]

44

In the digital museum age, digital images which include metadata standards to describe and deliver images (see III-F) [52] are state-of-the-art. High-resolution images allow users to zoom in on a virtual object, which would not be possible in physical museum space. In order to do that, digital humanities use the standard III-F.

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The use of 3D-techniques in particular can bring new insights to the investigation of materiality and object biographies, which can be useful in a certain way, both for research purposes and for communicating objects. Special tools not only support zoom factors for high-resolution images, but also 3D object data. Such tools need to include an audio response, multimedia offers and 3D animations based on 3D scans to consequently augment conventional museum reality to extended forms of museum presentation in today's digital age. Various different surfaces and responsibly designed media allow visitors to access museum data using various forms of output mediums.

46

Such tools can also contribute to engaging visitor attention [Bitgood 2016], because of the greater mental effort involved in browsing through object stories of one's own accord, additionally supported, for instance, by audio and image animations, 3D-object visualisations and virtual guided tours in online exhibitions and – vice versa – in physical museum space as well.

47

As regards physical museum space, all of these tools can help combine object biographies and the context information of objects in accordance with the visitor's personal interests and needs. For that purpose, digital media used in the classic museum space can complement conventional museum labels. Extending conventional museum spaces by means of digital technologies can be achieved in displays using replicas printed in 3D. These replicas address groups of visitors, such as children, who perceive certain effects by touching the 3D copies and experience these objects in that particular mode of perception. Moreover, the aspect of augmented reality can enhance visitor experiences of museum objects by using immersive technologies that involve the visitors in the content.

48

Immersive methods (see Dowling [2019]) are a means of special communication also used in physical museum exhibitions to engage in a narrative or storytelling process, thus provoking a condition of flow. This status can also be evoked in the virtual world by means of various tools, offering, for example, digital storytelling using augmented reality methods (for technical implementation, see Yuan [2019]).

49

Impacts of virtual museums

All of these possibilities of linking and enriching the web with museum object metadata also serve the purpose of extending conventional and modified museum space to create a kind of "public museum ecosystem" [Hartig 2019], and hence to offer extended visitor and user experiences in the virtual space. Conversely, conventional museum space is able to integrate virtual museum experiences such as 3D techniques and augmented reality. However, in that way a museum representation in virtual space can rely on the extended space of museal experience. As a result, the extended

50

museum space of a virtual museum has manifold impacts in terms of museology, digital humanities, museums and visitors.

In terms of museology, virtual museum space serves to extend conventional physical museum space in multiple ways: by enriching museum object data digitally, communicating with visitors with the help of social media, offering access to digital object databases and online exhibitions, or providing 3D views on objects in the virtual world. Furthermore, an extended conventional museum space virtually maps manifold object data and their stories, such as museum object-related contextual information. It communicates narratives and relationships of and between museum objects and collections. A virtual museum integrates various forms of communication used within physical museum space, such as guided tours, lectures and presentations offered by museum staff, thus augmenting conventional museum space by using its own 3D views. Also, a virtual museum represents the classic museum space three-dimensionally and links all possible museum object stories, images, 3D views, and storytelling tools to provide users with a virtual reality-assisted museum space based on museum objects and their relations to society, which always build the point of reference. Against this backdrop, it becomes clear that virtual museum reality strives to extend the theoretical approach of general museology into virtual space, as well as clarify aspects of authenticity and space to which a museum object is linked.

In terms of digital humanities, standards in museum object documentation and data enriching need to be extended by including museological aspects. Furthermore, a virtual museum uses a wide array of (immersive) digital methods and tools for special visualisation requirements which need to be further developed as regards the aspect of museology. Impacts for digital humanities or informatics also concern data storage and the provision of access to object data. Establishing a virtual museum means storing a large amount of data in terms of high-resolution images, videos or 3D copies as well. It must be able to support the process of dealing with complex user queries concerning various knowledge systems and object stories. On this basis, it is possible to manage complex collection analyses with reference to the uniqueness of museum objects.

An issue that goes hand in hand with that is the amount of time needed to load data and to process complex queries, which can influence visitor behaviour when browsing through the collections, and subsequently also the decision and will to visit a conventional museum. Managing personal and institutional data as well as image data, which involves applying for special licences, are hard facts (see Creative Commons licences).[53]

As a result, visitors and users browse through virtual museum space, selecting and experiencing museum object reproductions, virtually combined with manifold museum object information, context data and storytelling narratives. Users gain virtual access to the aspect of authenticity of museum objects, which means linking up objects and object data, and depicting and representing object relations related to a specific relevant event, to which an object bears witness. This access is independent of opening hours and physical accessibility, and at the same time, it does not replace the original object's authenticity.

The aspect of open access to museum collections in the form of a virtual museum reality is of special relevance in times of crisis, which the ongoing recent global Coronavirus crisis has clearly shown, as long as users have access to the internet. International museum organisations have requested museums to enlarge their digital communication strategies to provide museum visitors with information about their collections. For example, UMAC (the international committee for university museums and collections in the context of ICOM international) provided webinars to the professional university museum community to enable discussion on the impacts of the lockdown especially for university museums (UMAC ICOM).[54] One year on, many initiatives have found their way to various users, such as the virtual museum of the University of Cantabria (Luis Quintanilla, Art and Memory).[55]

Consequently, it is of great importance to mention the manifold effects this has had on museums. Museums can use a virtual museum as a tool to communicate museum object data, context information, storytelling and narratives, in order to provide access to their collections, which is crucial for museums in times of crisis, as the Coronavirus crisis has revealed. Museums can grant access to their collections even in times of official administrative closures, in times of war or at any other time when museums are forced to close their collections to the public. Moreover, in terms of the (military) destruction of museum objects or attacks in areas of conflict, virtual museum space could enable access to museum

object and collection data, and at the same time facilitate (at least) digital preservation. Even in times of a long-term shutdown and museum closures, exemplified by the present Coronavirus crisis, which is only one of various other options, virtual museum space has manifold effects on museum employees. As a research infrastructure, virtual museums could grant online access to museum employees to enable them to work from home on their museum communication projects. Additionally, a virtual museum could provide virtual visits to the museum, such as a digital video call, to complement the personal encounter. Conversely, all of these tools can influence the attractiveness of the real and physical encounter in times of physical visiting. By integrating these tools into physical museum presentations, they could help to deepen museum communication between museums and their visitors within physical museum space.

Of course, museums are challenged in times of crisis, especially with a view to heavy losses of entrance fees. On the other hand, museums would be obliged to consider concepts of gaining money by visiting virtual museums like other providers of digital services do. As the Coronavirus crisis has shown, the Internet and online possibilities have played an enormous social role in terms of replacing physical interactions between persons in order to phone, shop, to obtain medical attendance, schooling and university teaching, to access online sports programmes offered by local fitness gyms, and to enable museums and visitors to communicate with each other. However, none of these tools are able to replace real experiences or physical encounters – both mediums are different and aim to serve different manners of perception. These digital tools were a time-limited possibility due to the necessity of physical distancing. What the crisis has also shown is that some target groups were focused on the virtual world and perfectly happy to consume digital and virtual offers. For museums though, it is possibly interesting to note that some non-museum visitor target groups were much more attracted to digital museum features than to physical museum spaces. It is against this specific backdrop that museums should consider which impact a virtual museum can have on the audience and how museums can benefit from those effects.

Conclusion

The virtual museum refers especially to the processes of collecting, gathering, structuring and visualising data of museum objects or rather of the cultural heritage. This means to manage data, reference objects to scientific knowledge systems, map the information to XML-standards, visualise information and provide access to objects that are linked to their appropriate metadata and context information. For a standardised museum documentation process, a museum database providing all the needs of the digital humanities and of museology is essential, as the use of Excel spreadsheets or Word templates have turned out to be impractical for museum work.

The aim of a virtual museum is therefore to ensure that all visualisations take object biographies into account and that they link data to the very uniqueness of the objects and their relations in order to present a multi-layered view of those objects. In addition, virtual museums should also seek to impart narratives and thus address visitors emotionally in both the virtual and conventional museum space. This is done by integrating digital and immersive tools and methods in the process of representing conventional museum space in the virtual world. The extension of conventional museums into virtual space thus results in an interesting and attractive space where the joy of discovery is possible in an extended museum experience.

Finally, it is important to point out that despite all of the impacts a virtual museum may have, it is definitely a challenge to implement it. In that sense, the digital museum documentation standards mentioned above have many advantages in terms of data harvesting, but the process of modelling and mapping the data is a very complex and time-consuming one. For the practical museum documentation process, it is of special importance that a database is able to fulfil all of the purposes of recording data, processing and linking information. Currently, the only digital infrastructure available is WissKI which can fulfil all the requirements mentioned above, in accordance with the international museum documentation standard CIDOC CRM. However, that gap between theory and practice can be bridged by exploring the virtual museum as an interdisciplinary and transdisciplinary field of investigation.

This approach to virtual museums as an interdisciplinary and transdisciplinary object of investigation in the extended virtual museum space specifies further research desiderata specifically linked to the digital world. These desiderata address visitor studies and types of visitor behaviour in virtual space, for example, surfing and consumer behaviour, and

questions as to which contents visitors would like to experience or even if they would be willing to spend money on visiting virtual museums.

Evaluations of classic museum spaces showing their effectivity need to be extended to the virtual museum to question their ability to affect and to engage visitor attention. Methods used by empirical social studies such as psychology and communication sciences are thus combined with computer-supported methods and analyses such as eye-tracking.

<div style="text-align: right">62</div>

In conclusion, a virtual museum space provides manifold potential for museology and digital humanities to extend interdisciplinary and transdisciplinary methods and offers multiple impacts for museums and visitors to improve their presentation and communication strategies, not only in times of crisis. One important factor is that virtual museums are also able to target new groups of visitors and users, which would have to be investigated in detail in terms of their special needs.

<div style="text-align: right">63</div>

Until these requirements of virtual museums are achieved using interdisciplinary and transdisciplinary methods, the virtual museum will remain a *gedankenexperiment*, an interdisciplinary and transdisciplinary object of investigation.

<div style="text-align: right">64</div>

Notes

[1] Various approaches and disciplines, such as museum studies and media theory, deal with expanding museum communication by using the term virtualisation or virtual museums, see: Niewerth (2020), 521-532.

[2] See also University of Graz: https://gams.uni-graz.at/context:vm; and ViMM (Virtual Multimodal Museum), definition: https://www.vi-mm.eu/2018/01/10/the-vimm-definition-of-a-virtual-museum/

[3] See German Wikipedia entry "Digitales Museum:" https://de.wikipedia.org/wiki/Digitales_Museum

[4] See ViMM (Virtual Multimodal Museum), definition: https://www.vi-mm.eu/2018/01/10/the-vimm-definition-of-a-virtual-museum/

[5] ICOM: https://icom.museum/en/resources/standards-guidelines/museum-definition/

[6] See entry "Virtual Museum" in English Wikipedia: https://en.wikipedia.org/wiki/Virtual_museum

[7] VIMM, definition: https://www.vi-mm.eu/2018/01/10/the-vimm-definition-of-a-virtual-museum/

[8] See entry "Digitales Museum" in German Wikipedia: https://de.wikipedia.org/wiki/Digitales_Museum

[9] See for example: Technisches Museum Wien (https://www.technischesmuseum.at/das-digitale-museum); Kunsthistorisches Museum Wien (https://www.khm.at/)

[10] Europeana: https://www.europeana.eu/portal/en

[11] Deutsche Digitale Bibliothek: https://www.deutsche-digitale-bibliothek.de/?lang=en

[12] LIDO (Lightweight Information Describing Objects): http://network.icom.museum/cidoc/working-groups/lido/what-is-lido/

[13] CIDOC-CRM (Conceptual Reference Model developed by Documentation Standards Working Group within the context of ICOM): http://www.cidoc-crm.org/

[14] For German speaking areas, see museumvok: http://museum.zib.de/museumsvokabular/index.php?main=download&ls=9&co=we&ln=de

[15] For Anglophone areas, see Getty arts and architecture thesaurus: https://www.getty.edu/research/tools/vocabularies/aat/; which is also in the progress of translation into German language, see Getty Arts & Architecture Thesaurus German, see: http://www.aat-deutsch.de/aat_info/

[16] National Museum of Natural History, Smithsonian Institution: https://naturalhistory.si.edu/exhibits/bone-hall

[17] See Google Arts and Culture: https://www.google.com/culturalinstitute/beta/?hl=de

[18] For example, the Pergamon Altar: http://3d.smb.museum/pergamonaltar/

[19] Originally in German: "Musealität ist die Beziehung des Menschen zur Realität, in der er in Übereinstimmung mit seiner Gesellschaft erkennt und bewertet, welche Teile der ihn umgebenden natürlichen und gestalteten Welt imstande sind, als Nachweise dieser Gesellschaft zu fungieren und es daher verdienen, als Träger dieser Beziehung erhalten, systematisiert, erforscht, vermittelt und tradiert zu werden" [Waidacher 1999a, 708].

[20] See the online museum display of the above vehicle in the Heeresgeschichtliches Museum in Vienna: https://www.hgm.at/ausstellungen/dauerausstellungen/das-attentat-von-sarajevo-28-juni-1914

[21] LIDO is the Lightweight Information Describing Objects (http://network.icom.museum/cidoc/working-groups/lido/what-is-lido/). CIDOC-CRM is the Conceptual Reference Model developed by Documentation Standards Working Group within the context of ICOM (http://www.cidoc-crm.org/). See also Biedermann (2017a).

[22] GAMS: https://gams.uni-graz.at/archive/objects/context:gams/methods/sdef:Context/get?mode=&locale=en

[23] See Trier University: http://www.dhmuseum.uni-trier.de/

[24] See Wörterbuchnetz – hosted by the Trier Centre for Digital Humanities: https://dhmuseum.uni-trier.de/node/42

[25] Göttingen Centre for Digital Humanities: https://www.gcdh.de/en/research/topics/ and Göttingen Centre for Digital Humanities initiative on Linked Open Cultural Heritage Data: https://www.gcdh.de/en/research/topics/linked-open-cultural-heritage-data/

[26] Project Zafar at the University of Heidelberg: https://www.uni-heidelberg.de/fakultaeten/philosophie/zaw/klarch/forschung/3Dzafar.html

[27] Herder Institut in Marburg: https://www.herder-institut.de/en/research-projects/completed-projects/digital-3d-reconstructions-in-virtual-research-environments.html

[28] GAMS virtual museum: https://gams.uni-graz.at/context:vm

[29] The DiTAH project (Digital Transformation in Austrian Humanities) focuses on the infrastructure and the tools and methods needed to transfer research data to the public. In this context, cultural heritage data also plays an important role. The university museums at the University of Graz are also project partners and use the data of historical instruments for this analysis; see: https://www.ditah.at/.

[30] TEI: www.tei-c.org/index.xml

[31] XML (Extensible Markup Language) is a simple, very flexible text format (see XML: http://www.w3.org/XML/).RDFa is a specification for attributes to express structured data in HTML5, XHTML and any XML application (see RDFa: https://www.w3.org/2001/sw/wiki/RDFa).JSON-LD is a lightweight Linked Data format (see JASON-LD: https://json-ld.org/).

[32] RDF (Resource Description Framework) is a standard model for data interchange on the Web (see RDF: https://www.w3.org/RDF/).SKOS (Simple Knowledge Organization System) is a common data model for sharing and linking knowledge organization systems via the Web (see SKOS: https://www.w3.org/2001/sw/wiki/SKOS).OWL (Web Ontology Language) is a Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things (see OWL: https://www.w3.org/2001/sw/wiki/OWL).

[33] XSLT (eXtensible Stylesheet Language) is used to define XML document transformations and presentations. It transforms XML documents into other XML documents (see XSLT: http://www.w3.org/standards/xml/transformation#xslt).

[34] XSLT-FO (Extensible Stylesheet Language – Formatting Objects) is used to transform XML-documents for printing and viewing (see XSLT-FO: http://www.w3.org/standards/xml/transformation#xslfo).

[35] Institut für Dokumentation und Editorik: https://www.i-d-e.de/

[36] XQuery (XML Query Language) is used as a standardised language for combining documents, databases or Web pages (see XQuery: http://www.w3.org/XML/Query/).

[37] XPATH (XML Path Language) XPath is used for identifying parts of an XML document (see XPATH: http://www.w3.org/standards/xml/transformation#xslfo).

[38] For example, by means of AMS (Asset Management Systems) which is used for sustainable, metadata-based and citable archiving and flexible access to digital resources (see GAMS, which is an "asset management system for the management, publication and long-term

archiving of digital resources from the Humanities:" https://gams.uni-graz.at/archive/objects/context:gams/methods/sdef:Context/get?mode=&locale=en). For European initiatives, see CLARIN: https://www.clarin.eu/ and website of Dariah-EU: https://de.dariah.eu/).

[39] WissKI – an innovative virtual research infrastructure, compliant to the CIDOC CRM: http://wiss-ki.eu/

[40] Objekte im Netz: http://objekte-im-netz.fau.de/projekt/

[41] https://antike.uni-graz.at/de/museum-sammlungen/archaeologische-sammlungen/virtuelles-museum-der-archaeologischen-sammlungen-der-universitaet-graz/

[42] XSLT: http://www.w3.org/standards/xml/transformation#xslt

[43] https://www.oxygenxml.com/

[44] http://www.tei-c.org/oxgarage/

[45] LIDO (Lightweight Information Describing Objects): http://network.icom.museum/cidoc/working-groups/lido/what-is-lido/

[46] CIDOC-CRM (Conceptual Reference Model developed by Documentation Standards Working Group within the context of ICOM): http://www.cidoc-crm.org/

[47] WissKI: http://wiss-ki.eu/

[48] https://www.w3.org/2001/sw/wiki/SKOS

[49] https://openglam.org/

[50] PDF is a Portable Portable Document Format to present documents independent of application software and operating systems.XHTML (EXtensible HyperText Markup Language) extends HMTL (Hypertext Markup Language) the language to formulate webpages and structures and semantically annotates texts.SVG (Scalable Vector Graphics) is an XML standard to describe two-dimensional vector graphics.SMIL (Synchronized Multimedia Integration Language) is an XML-based standard to describe multimedia presentations.

[51] https://storymap.knightlab.com/

[52] III-F (International Image Interoperability Framework) defines interfaces to provide standardised methods of describing and delivering images via the web (see III-F: III-F: http://iiif.io/).

[53] https://creativecommons.org/share-your-work/licensing-types-examples/

[54] http://umac.icom.museum/resources/webinars/

[55] https://web.unican.es/campuscultural/Paginas/Luis-Quintanilla-arte-y-memoria.-Museo-virtual.aspx

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