The intangibility of tangible objects: re-telling artefact stories through spatial multimedia annotations and 3D objects

Keywords

3D objects, multidimensional space, multimedia annotations, storytelling, web technologies

Abstract

An interdisciplinary team at the University of Cologne just released Kompakkt, an open-source[1] online-tool[2] for linking 3D objects to multimedia content and for gathering information through annotations in 3D space more generally. It enables users to share, explore, and collaboratively annotate objects in standard modern web browsers. The 3D representation of an object serves as the hub of an open-ended collection of heterogeneous information established through the use of multimedia annotations. The annotations are flexible (meta)data complementing what one usually finds in collection management systems in the GLAM sector. Through personalised and group level collections of 3D models, images, sounds and videos Kompakkt enables a novel solution for gathering and generating artefact information. The third dimension of objects highlights the perspective of annotations in a new way: annotations are not only linked to a specific location in space, the corresponding point of view chosen by the user is also relevant. Linking and ranking annotations leads to moving from one annotation (and a specific perspective) to another, which implies a movement through space in time. That allows new ways of annotation-based storytelling, where annotations can be used for presentations in which movement in VR- and AR-applications is embedded.

[1] The whole source code is available under: https://github.com/DH-Cologne/Kompakkt (GNU Affero General Public License v3.0).
[2] See https://kompakkt.uni-koeln.de.

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Introduction: Show what you got – dead or alive

Most museums exhibit physical objects. This enables the mediation of knowledge through contextualizing artefacts within the experienced reality of the observer. Objects act as a starting point for the exchange and generation of various kinds of knowledge.[3] Moving an object around enables us to see new things in a concrete way, it sheds new light on the object. This can also happen at more abstract levels and not just through the original but also through replica and in the process of creating replica. This is well known from several areas of research based on material culture including theatre studies and experimental archaeology.[4] Usually physical handling of museum objects is not available to the visitors. For many types of objects this leads to a risk of losing their interactive character, also in cases where it was an important part of their cultural energy.

The widespread use of digitised versions of museum objects shows that we do not always need haptics and a physical presence for useful interaction and for gathering knowledge. The availability of digitised object images with corresponding metadata is important for the management of museum collections. But it does not fulfil the potential of the digital space to negotiate the various cultural and historical aspects reposing in the materiality of an artefact. Therefore it fails to produce and provide *contextualised digital objects*[5] in which an experience of the *affordance*[6] of the artefacts can be made accessible.

The need to contextualise cultural artefacts is important in scholarship, not least in the field of theatre and performance studies, which from the outset was based on the availability of highly context dependent theater artefacts. Carl Niessen (1880-1969) was key in the process of dissociating theatre studies from literary studies. He founded the theatre museum in Cologne in 1919[7] as part of building up a new discipline based on the study of performances. TWS is now one of the leading theatre collections in Europe and highly interested in the

[3] See, e.g., A History of the World in 100 Objects (MacGregor, 2010).

[4] For a well known example see Heyerdahl (1948). The building as well as the use of the replica artefact was used by the participants of the Kon-Tiki expedition to establish knowledge. Such use of replica is a standard method for learning from interacting and does not guarantee that what one learns is correct; it always has to be interpreted in context. This is also the case for virtual replica.

[5] *Contextualised digital objects* refer to the digitised objects, which are captured while paying special attention to their registered cultural context. In an act of transcending their physical form, such digitalisation allows a direct access to the symbolic meaning of the objects (Türkoğlu 2019).

[6] With 'affordance' we intend the meaning of Gibson (1986: 130): "The object offers what it does, because it is what it is."

[7] Since the 1980s *Theaterwissenschaftliche Sammlung der Universität zu Köln (TWS).*

potential of 3D digitalisation and visualisation. Niessen's work led to a focus shift from texts of classical plays to heterogeneous theater artefacts as objects of study (Fischer-Lichte 2013: 13). This involved seeing these objects as carriers of information about ephemeral events such as performances. In Carl Niessen's exhibitions and his so-called *lecture performances* in the early 20th Century he restaged and re-animated performative objects such as masks and puppets, as well as other kinds of interactive objects including stage models and figurines (Probst et al. 2019). This shows how historical artefacts have the potential of being a scholarly storytelling medium through which we can gain access to different historical contexts which were assumed to be lost in time. He states about his *lecture performances that* "Ein bloßes 'Theatermuseum' ist nur die zerbröckelte Mumie eines schönen Körpers, wenn nicht ein Kundiger mit der Magie des lebendigen Wortes die Teile in der mitgerissenen Phantasie ergänzend zusammenzufügen vermag" (Niessen 1926, cited in ibid.).[8] While this statement expresses the need to re-contextualise usage-oriented objects in museums, the core meaning can also be rethought through digitalisation and the practice of digital cultural heritage management. A digital image with metadata alone represents just the shadow of what an object is capable of. The artificial form of computer based interactive spatiality, on the other hand, has a potential of expressing more aspects of what a physical object can be used for and thus to decipher its significance in a reusable and expandable way. This expresses one of the claims that was essential for the development of the application.

(Re)vivify objects through interactions in a non-material virtual space

The tension between digital reproductions and the complexity of the reproduced physical artefacts is obvious. No transformation from one form to another can capture everything (Elleström 2010; Eide 2015). While having a potential for abstraction which can often be productive, it also puts limitations on the use of digital collections. Different solutions to this problem has been presented and implemented over the years. Meanwhile the creation of digital three-dimensional reproductions, which can contribute to the gain of knowledge through the modelling process itself,[9] has become significantly easier thanks to technical developments in photogrammetry and better open source tools to process the

[8] "A mere 'theatre museum' is nothing more than the crumbled mummy of a beautiful body, unless an expert, with the magic of the living word, can reconstruct and complement the pieces in his stirred up fantasy."
[9] The whole life cycle of model creation and use has an epistemological potential (Ciula et.al. 2018).

photogrammetrical data faster with lower financial costs and less manual work. This allows a rapidly growing number of 3D replicas produced for institutions and for traditional humanities disciplines without a long tradition of technology use or use cases in the field of 3D.

One motivation for the development of Kompakkt results from JavaScript frameworks in conjunction with HTML5, WebGL[10] and WebXR[11] because it ensures online access through allowing the display of three-dimensional models in the web browser without plugins or additional software.[12] Along with an adequate representation the ability to explore and interact efficiently is a core feature of such systems. This, however, poses technical problems as well as problems with media representation; that is, not only the representation of the object but also the process of creating the representation and the medium around it (Elleström 2014).

While multimedia annotations of 3D objects has still to find their place in GLAM institutions, annotation as an undisrupted, reusable and expandable method in itself is closely connected to well established scholarly methods in the humanities and cultural heritage information collection and exchange.[13] This leads to the idea of using a 3D object through its digital 3D representation as a starting point for generating, systematically collect, and exchange information. This is especially useful in interdisciplinary research processes where people with diverse backgrounds, research questions and purposes work collaboratively. The relevance of the object for the research topic can be more or less clear from the outset. In some cases the link to the object of study is obvious and the object itself clearly stand in for a broader phenomenon. The object can serve primarily as a reference or starting point for the collection of heterogeneous information. The scope and amount of information to be linked to the object is open ended and cannot be defined in advance (Haveman et.al. 2008; Eide 2015). Annotating objects by adding information and interlinking them represents a less schematic way of collecting metadata than what we often see in museum management systems. Enriching information through annotations can become an additional method for collecting metadata, where one partly records information that reflects object properties and partly documents the research processes linked to the object. The interaction with the

[10] See, e.g. https://developer.mozilla.org/de/docs/Web/API/WebGL_API.
[11] See, e.g. https://www.w3.org/TR/webxr/.
[12] See, e.g. *3D Heritage Online Presenter* (Potenziani et al. 2015).
[13] See Grafton (1997) for a general overview.

object itself can already be ascribed to it and recorded in digital space by an appropriate recording of the user interaction. An annotation, which can also establish connections between objects, is always produced in time and space through an activity. Through recording this activity in Kompakkt we are in line with state of the art methodology in cultural heritage documentation (Le Boeuf 2018).

Before these theoretical explanations can be transformed into a description of a concrete software application, clearly identifying the concepts that result from the explanations is necessary. Distinguishing the concepts behind annotation not only from other concepts but also from similar concepts in different contexts becomes possible when trying to implement and make available software for annotating in multidimensional space. The attempt enables a rethinking of deliberations of annotation in scholarly research thus far as the following descriptions and the use of the software will show.

Expressing theoretical considerations through the actual implementation

For the implementation of an application based on the considerations outlined above, technical aspects and the programming itself must be taken into account. Of course, these are strongly dependent on the intended use, but they also influence the concrete implementation, shaping the result in an interplay between scholarly goals and technical possibilities. The aim was to develop a web application that is designed to give access and enable exploration and interaction through multimedia annotations in a collaborative environment. In order to fulfil this intention, a repository[14] and an integrated viewer[15] for the heterogeneous objects, 2D as well as 3D, has been implemented. Kompakkt is an open-source web application built on the framework Angular (Angular 2019) and the web-based graphics engine Babylon.js (BabylonJS 2019). Thanks to WebGL and the WebXR Device API, the development of 3D applications for the web is now quite doable. The application can also be used offline and is available across platforms. It requires no additional installation of software beyond the use of a modern web browser[16].

[14] Source code is available here: https://github.com/DH-Cologne/Kompakkt.Repo/.
[15] Source code is available here: https://github.com/DH-Cologne/Kompakkt.Viewer/.
[16] Supported Browsers are listed under https://caniuse.com/#search=webgl.

The setup of the repository was based on well established practice and will not be discussed in any detail here. The development and integration of the viewer for the representation and interaction with the heterogeneous digital objects was more innovative and forced us to confront a number of conceptual challenges. Central to this was on the one hand the consideration of what an object is and how it can be represented, and on the other hand, the examination of contextualization and information enrichment through interactive annotations.

As part of the conceptual analysis we had to find out what makes up an object in the context of Kompakkt. An object is added to the repository due to its relevance, that is, because it is of (research) interest and somebody wants to explore or annotate it (1) or because it seems interesting for the contextualisation and referencing of another object in the repository and should be used and represented as part of the content of an annotation (2). These intentions are not contradictory. Objects initially added as annotation content (2) can themselves be used as a starting point for further annotations (1) and vice versa. Supported media types for annotations are sound, image, moving image (video) and 3D-models, whereas images and 3D models can also be the targets of annotations. Implementing annotations of video and audio data is planned for the next version.

All these different types of objects are visualized in 3D space; in the case of audio by a placeholder and control elements. Some of the objects have an associated physical object (the source), while others are born digital and could not even be translated into the world outside computers and projections, e.g., CGI elements used in cinema, theatre or other art forms.[17] In the context of Kompakkt these objects are collected and not only referred to. They also appear visually. In addition to specifying general standardised metadata that refers to the object as a whole and is collected through an interface for entering metadata during the upload process,[18] there is also an additional way to enrich the dataset.

Through the annotations, a system for interactive exploration and embedding which can also be used for storytelling is made available. An annotation is created by double clicking somewhere on an object. The selected point in space is then saved and the creation of an

[17] An interesting example would be the Tempest performance made by Royal Shakespeare Company in cooperation with Intel, in which Ariel is depicted as a 3D model but controlled live through motion capture of an actor. With Kompakkt it is possible to make such avatars interactively accessible as an animated model, created from motion capture (“400 Years in the Making” 2017).

[18] The data model for objects in Kompakkt is compatible with CIDOC-CRM (Le Boeuf 2018).

annotation is initiated. In Kompakkt, the target point of the annotation is represented by a small 2D circle. The circle contains a number representing its place in the ordered list of annotation. The user's point of view when the annotation is made is also captured through recording the actual camera settings reflecting the users perspective on the object. This becomes part of the documented annotation itself. It is also the prerequisite for another implemented feature, the so called *walk-throughs*. In cases where more than one annotation exists for one single object, additional control elements appear in the interface. It allows the user to navigate from one annotation to another with an animated camera, given that different perspectives are related to different annotations. This movement can reproduce the settings of the camera used in the recording of the 3D model. The body of an annotation can include multimedia objects, or be left empty if only the perspektive is relevant. The user may add texts, images, 3D models, audio files from the Kompakkt repository, or a link to another web resource. These can in themselves also be annotated, also with references to other objects. In principle this allows for an endless network of entities. The content of an annotation appears in a small box, an html element, which is dynamically positioned next to the marker of the annotation. Even if the camera moves around the object, the selected point and the body of the annotation will be correctly located. The box can be closed, but the marker never disappears—it is visualised transparently if it would have been covered by the object through the camera moving to the perspective chosen by the user.

Kompakkt is a web application. Thus, any object can be visited by different users in parallel. They can also be informed about the presence of other users, allowing online meetings in virtual space. Kompakkt can be used for collaborative work though the possibility of concurrent annotations, that is, annotating together with other users in real time.[19] Users can invite other users to annotate an object and to work on annotations together. The changes can be observed by all collaborating users, who are kept visually informed in real time about annotations that are created, edited or removed by other users.

[19] The realtime application framework Socket.IO (https://socket.io) was used to implement concurrent annotations.

Registered users[20] are invited to create annotatable collections of objects from the repository. A collection includes all relevant material to start annotating an object: the object itself but also the objects to be used as part of an annotation. They can also upload their own material. This can then be shown, with its added annotations, as part of other websites by embedding it through an iframe. Collections can be private, restricted or open to all users, and individual as well as collaborative annotations can be allowed. All in all, the features described here allow users to show their objects, search for relevant objects, annotate and tell stories, and to prepare presentations alone or in collaboration with others.

Combined theory and practise in action: use cases for Kompakkt

The Kompakkt's proof of concept described in what follows derives from TWS, the Theater Collection at the University of Cologne. Different types of objects from the collection have been digitised to test the possibilities and limitations of the implementation.[21] One example is Johannes Schröder's revolting stage model for the Egmont performance from 1928-1929. It is one of the early examples of revolting stages in Europe and has the special feature of allowing the performance to keep going without the need of closing the stage curtain to change the scene.[22] The effect was cinematic in the sense that changing the place of the scenery was undisturbed by a curtain break. Interestingly enough the process of three-dimensional digitisation forced us to rethink the object and its intended use. This made it clear that Egmont as a play has more scenes than the stage alone can provide. Further investigation revealed that the sides of the stage must have been reused for multiple scenes, creating different places through the use of different props. With Kompakkt it is possible to annotate the Egmont stage model with Schröder's drawings, which resurfaced during the research process (Picture 1). They show the multiple uses of parts of the stage in different scenes. Since every annotation has a position and is given a camera perspective, one can wander through scenes of Egmont with the point of view according to the given scene, in addition to the possibility of moving around the model

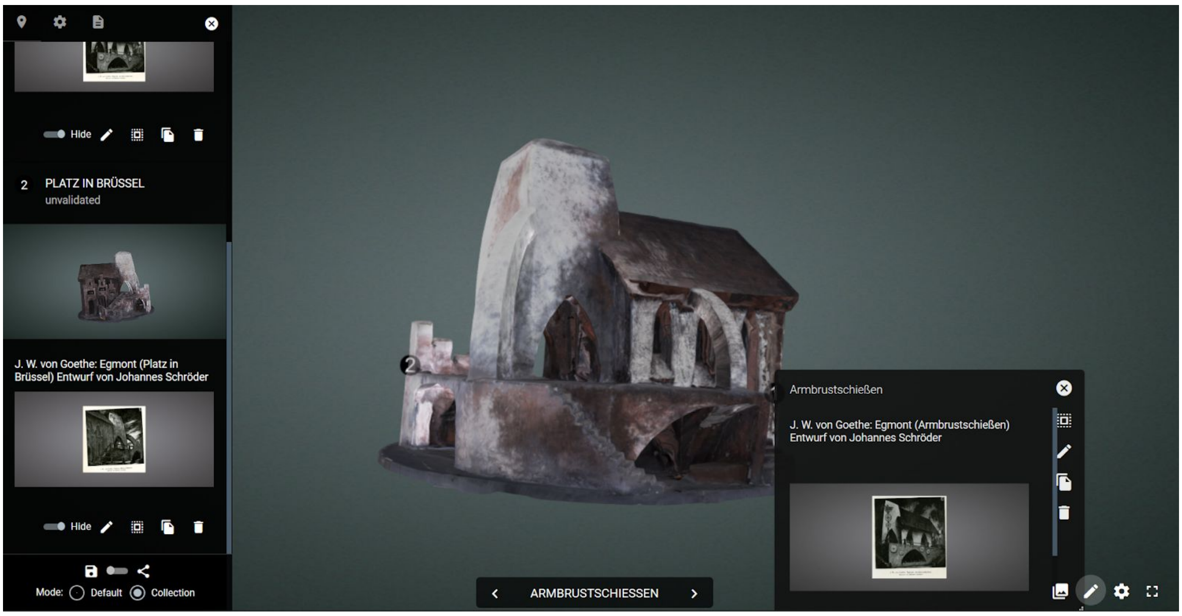
[20] Everyone accessing the website can create an account and additionally ask for the permission to upload objects. The LDAP integration allows users from the University of Cologne user management to log in without registering.

[21] For the first test phase, a total of 64 objects were 3D-digitized using a white light scanner (AICON SmartScan-HE). Four more objects were processed photogrammetrically.

[22] Even earlier examples are found in the japanese kabuki theatre, such as the stage design known as a "mawari butai" dating back to the 1750s.

freely. In this case Kompakkt is not only used to present an experience of the stage model with added Information, but it also serves as a cataloging tool to group and combine related objects. Annotation allows the organisation of related objects as multidimensional collections, which can be very beneficial for lectures, exhibition planning, as well as in the preparation of publications.

Performative objects such as masks profit not only from the rendering of form, color and surface texture, but also from the possibility of tilting the model, viewing it from different sides and angles. This is especially true in the case of japanese Noh theater masks, where the mask can have different perceived expressions depending on the angle of the head position of the actors. These expressions include the impression of fear, pain or sadness, if the point of view is turned upwards to the mask; if it is seen from an angle above, the expression changes into an angry or maleficent one (Picture 2). Noh-actors use those expression changes from one position to another to produce the illusion of actual facial muscle movement. Kompakkt allows to experience these different expressions and illusions, either freely or through annotations. It is also possible to explore the backside of the masks, which are often hidden in exhibitions. A physical exhibition of an object accompanied by interactive models would extend the affordances of the object.



Picture 1: Screenshots of the 3d model of Egmont stage model with an annotation of Schröder’s drawing

Picture 2: Screenshots of the 3d model of a Hannya mask from Kompakkt.

Conclusion: results, further development and research potential

The application Kompakkt, which has been presented here, enables interactive use of multimedia annotation of objects in 3D and thus creates an extended possibility for the collection and mediation of information in the in the GLAM sector. The full potential of the application emerges when many users share and collaborate for their research goals and use it as a method to gather information. The collaborative real time annotation feature is intended to promote this. As the above examples show, the use of Kompakkt can enable a useful combination of information, whereby the representation also makes interactive access possible. Storytelling expands the possibility of revival for archived and exhibited objects alike, especially for objects which have been used for interactions and on stage, as those related to theatre and performances. The immediate access to the object is complemented by user friendly ways to enrich information. Users from different disciplines can mark their point of interest and thereby add valuable information.

Already during the implementation and the first testing phase different ideas for additional features and the potential for further development came up. The first version of the software described here is focussing on annotations in space rather than in time. This means that data which is visually represented in digital space, such as a 3D model or an image, can be annotated. An annotation refers to the whole object or to a specified smaller part of the object. For video and audio possible smaller targets for annotations include frames, sequences, or specific time codes. As such media change over time, this opens up a new challenge for annotations of a visual space. It is planned to implement a functionality for this use case in the next version.

The selection of parts of a 3D object could be supported by predefined subobjects and specified parts of a mesh. Furthermore, an automatic detection mechanism for recognising forms and for suggesting their possible function would help to make not only the annotation of the objects but also later searches more efficient. Such a mechanism could suggest forms to the user, e.g., identify something as a door. This identification could then be suggested to the user who could check this suggestion. The result would be that one might be able to search for "door" in the repository and find all 3D models containing a door.

At the moment it is only possible to move the camera around an object. For objects with movable parts it would be an interesting feature to allow also movement of objects through user interaction.

Exploring a 3D object expressed through different camera positions chosen by the user can already be of specific interest. A feature to record more than one camera position and save them as part of one annotation would increase the existing possibilities to record information. Additionally a live screencast to broadcast the movement could be used for presentations with a distributed audience.

Also augmented reality could be established with the technologies used. Support for virtual reality has already been tested in Kompakkt. This is especially interesting because one of the limitations of many devices is the translation and realisation of movement through VR. By adding annotations, a path through the virtual space can be defined and the user just needs to switch from one annotation to the next one in order to travel through space and time.

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