Chapter 1
ART for Art Revisited: Analysing Technology Adoption Through AR Taxonomy for Art and Cultural Heritage

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1.1 Introduction

The world we live in is going through a constant change driven by technological advances. These have the power to revolutionise the way we live in a similar way as personal computers or mobile phones did in the past. Foreseeing which technology has such a potential is nearly impossible, however, it is becoming more and more evident that Augmented Reality (AR) is a good candidate and could have a similar social and economic impact on the shift of the computing paradigm.

However, the development of AR has been mainly pushed by technology, which is not optimal for wide-scale adoption because "*The technology tools are not an end in themselves, but a means to an end*" (Furness 2017). Hence, in the context of technology adoption and development, "*We should ask not only what, but so what!*" (Furness 2017). In order to pursue this goal, AR practitioners and researchers should focus on solving real-world problems based on the opportunities provided by technology and the identification of solvable problems worthwhile addressing. This can propel the development and uptake of any new technology, but pursuing this goal is not easy. In the case of AR, its lure is strong and unique as it enables profound coupling with human senses allowing for generating personalised perspectives in which digital information is being blended with what is coming from the real world. However, this coupling presents in itself a danger as it can interfere with a highly sophisticated human sensing ability of the real world, perfected over millions of years. As Furness highlights, "the mantra of AR should be do no harm" (Furness 2017).

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This chapter focuses on Augmented Reality technology (ART) in the context of art galleries, museums, and cultural heritage sites. The institutions running these sites are highly important as they are preserving, presenting, and communicating the arts and cultural heritage to humanity. However, nowadays, we live in the "time of plenty" where these institutions have to compete for attention and visitor numbers with several other ways of passing time such as entertainment-, edutainment-, or sport-oriented activities.

One of the possibilities to attract visitors to the aforementioned sites is finding the right way of integrating new technologies in ways that will enrich experiences offered. This is particularly important when trying to attract younger audiences. An extensive survey from 2003 has already showed that one third of European museums has already started to experiment with some sort of 3D graphical content (Mohammed-Amin 2015; Wojciechowski et al. 2004). This review resulted in 119 AR applications and/or prototypes for art and cultural heritage. It is thus clear that the institutions running art galleries, museums, and cultural heritage sites are already pursuing this goal. The ultimate goal of these institutions is to present and interpret their collections in appealing and exciting ways, creating experiences that will remain relevant to the modern-day tech-savvy visitors and attract new audiences (Gutierrez et al. 2008; Mohammed-Amin 2015; Wojciechowski et al. 2004). However, the remaining questions are: (i) how good is this adoption and (ii) how well do these institutions utilise opportunities created by advances in AR technology.

In this chapter, we provide an insight into the adoption of AR technology in art and cultural heritage. In pursuit of this goal, we first looked at different AR categorisations/taxonomies, but failed to find an adequate one. We thus propose the activity-based taxonomy method as a tool to provide an insight into technology adoption within a specific domain or context of use. We then use the proposed method to produce the AR Taxonomy for Art and Cultural Heritage (ART for Art and Cultural Heritage). We evaluate the proposed taxonomy and adoption of technology by classifying 119 AR applications in the domain of art, museums, and cultural heritage and discuss the results in light of good practices, missed opportunities, and future developments.

1.2 Activity-Based Taxonomy Method

Activity-based taxonomy method (Table 1.1) is a tool for gaining an insight into technology adoption within a specific domain. The classification of evaluated systems is based on building a model, which describes the domain with a set of domain-specific activities. Based on the model, systems are graded on how well they support each activity of the model. Any system can provide support for many activities; however, scores are only provided for supported activities and have a range from 1 to 3 (e.g. minimal, moderate, high support).

Table 1.1 Activity-based taxonomy schema

	Model			
	Activity 1 support score (1–3)	Activity 2 support score (1–3)	Activity 3 support score (1–3)	…
System 1	Support score (1–3)	Support score (1–3)	Support score (1–3)	…
…	…	…	…	…

Note that scores are only provided for supported activities

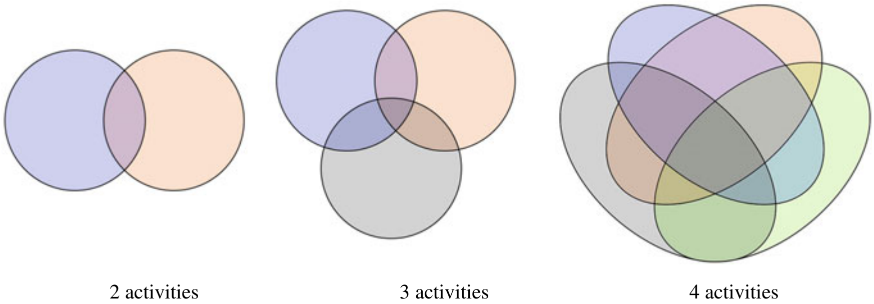

Fig. 1.1 Venn diagrams for 2, 3, and 4 activities

The groups that emerge from the classification can be visualised using Venn diagrams, which change based on the number of activities in the model. Visualisations of a model with 2, 3, and 4 activities can be seen in Fig. 1.1.

1.3 AR Taxonomy for Art and Cultural Heritage

In this section, we utilise the described activity-based taxonomy method in order to build the AR taxonomy for art and cultural heritage. In the first subsection, we propose an activity model of visiting a museum, art gallery, or cultural heritage site, which is then used to generate ART for Art and Cultural Heritage.

1.3.1 Activity Model

The proposed model of activity for visiting a museum, art gallery, or cultural heritage site (MAVM) is based on the MAVM proposed by Tillon et al. (2011). Tillon et al. (2011) based their model on two activities: analytical and sensitive activities. The analytical activity consists of the visitor exploring, dissecting, and objectifying the artwork. In other terms, it consists of contextualising the artwork situated into its original context. More specifically, this activity consists of precise description (diving into the details the artwork); objectification (placing the artwork into its context of creation within cultural heritage or historical space); and emergence of questions for the future.

The sensitive activity allows visitors to be more sensitive to impressions when viewing a piece of art and is comprised of three types of stimuli: immersion (relates to emergence of the visitor's feelings in the here and now); impregnation (relates to how visitor's feelings while in front of the artwork connect to feelings they experience in their daily life); and imagination (relates to the way the visitor can appreciate the artwork).

We expanded the MAVM of Tillon et al. (2011) by adding two additional activities: the communication and personalisation activities (see Fig. 1.2). Communication activity is a fundamental human activity commonly present when one visits a museum or an art gallery. The communication activity can involve various forms of communication: communication between the institution (e.g. gallery or museum) and the visitor, communication between collocated visitors, and communication between visitors and the outside world (e.g. sharing the visit experience on social networking

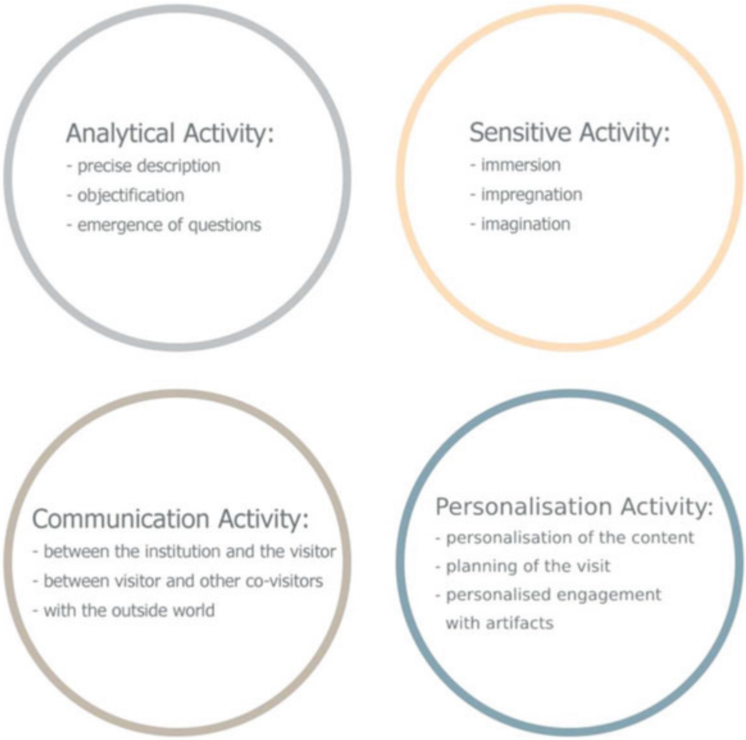

Fig. 1.2 Expanded model of activity of visiting a museum (MAVM). The proposed model complements MAVM proposed by Tillon et al. (2011)

sites). All these types of communication can happen before, during, and after the visit and can be seen as a vital part of a visit to the museum, art gallery, or cultural heritage site.

The personalisation activity can be user induced or automatic. There are many criteria upon which personalisation can occur, such as: personalisation of the content, personalisation of the visit, and personalised engagement with artefacts (e.g. curation of personalised art forms (Čopič Pucihar et al. 2016)). As highlighted by Sevigne and Matisse (Sevigne and Matisse 2007), such personalisation can address personal interests, learning styles, disabilities, age groups, level of initiation, available time for the visit, offline visit planning, or bookmarking.

1.3.2 Taxonomy

AR taxonomy for art and cultural heritage (Table 1.2) is activity-based taxonomy grounded on four activities of the MAVM (Fig. 1.2). To get an insight into technology that is being used, we also add the type of technology to the classifier. Throughout the classification process of 119 AR applications for art and cultural heritage, we identified four (4) different types of AR systems, all of which relate to augmentation of visual senses, namely: handheld AR—a system where display is held in hand or fixed on the stand, but can be manipulated using hands; spatial AR—a system where the environment is augmented by projecting light onto physical structures; mirror AR—a system where the mirrored reflection of the real world is augmented; head mounted display (HMD) AR—a system where the display through which augmentation can be observed is worn on the head of the user (this includes AR glasses).

1.4 Results of Classification

Using the proposed ART for Art and Cultural Heritage, we classified 119 examples of AR applications for art and cultural heritage. This was done in order to evaluate

Table 1.2 AR taxonomy for art and cultural heritage

	Type of technology (handheld, spatial, mirror, or HMD)	Model			
		Analytical activity support score (1–3)	Sensitive activity support score (1–3)	Communication activity support score (1–3)	Personalisation activity support score (1–3)
System 1	…	…	…	…	…
…	…	…	…	…	…

the proposed activity-based taxonomy and gain meaningful insight into the adoption of AR technology in the context of art galleries, museums, and cultural heritage sites.

AR applications were selected through a systematic search for articles on Google Scholar, IEEE Xplore, and ACM digital library. We used a predefined set of keywords and reviewed the first 200 search results selecting the ones where AR applications were presented within the paper. In the case of review papers, we explored referenced work in search of AR applications. Through the selection process, we decided to also include applications with descriptions only published at various websites. This was done in order to get a better understanding of what is used within galleries and museums outside the research domain.

The scoring and categorisation were done individually by both authors of this chapter. The scores were then compared and discussed in order to obtain a unanimous decision on the final score presented in Table 1.3. It is important to note the authors did not score how novel or technically advanced reviewed systems are, but focused on how well the systems support activities of the MAVM from user's perspective. It is also important to note that in the case of sensual activity, immersion is a very important factor; hence, high-quality rendering and the setting/environment in which the system was deployed could not be separated from the obtained score. To sum up, irrespective of all efforts to objectify the obtained classification scores, the results presented in Table 1.3 are subjective in nature. Nevertheless, they still provide valuable insights into adoption of AR technology.

The data in Table 1.3 is summarised by a Venn diagram that visualises the groups based on classification results (see Fig. 1.3). In the following two subsections, we further analyse the results of classification using descriptive statistics (Figs. 1.4, 1.5,

Table 1.3 Classification table of AR taxonomy for art and cultural heritage

Reference and technology	A	M	C	a	s	c	p
Jean-Michel et al. (2010) Video & On Stand							
Jean-Michel et al. (2016a) Spatial							
Jean-Michel et al. (2015a) Video & Handheld							
Jean-Michel et al. (2016b) Video & Handheld							
Jean-Michel et al. (2015b) Video & Handheld							
Jean-Michel et al. (2015c) Spatial							
Jean-Michel et al. (2015d) Spatial							
Jean-Michel et al. (2015e) Spatial							
Jean-Michel et al. (2013) Video & Handheld							
Jean-Michel et al. (2011a) Spatial							
Jean-Michel et al. (2011b) Video & Handheld							
Jean-Michel et al. (2011c) Spatial							
Valbuena (2010a) Spatial							
Valbuena (2010b) Spatial							
Valbuena (2004) Spatial							
Střelák et al. (2016) Video & Handheld							
Keil et al. (2013) Video & Handheld							
Miyashita et al. (2008) Video & Handheld							
Schmalstieg and Wagner (2007) Video & Handheld							
Bostanci et al. (2015) Video & Mirror							
Caarls et al. (2009) Spatial							
Han et al. (2013) Video & Handheld							
Gilroy et al. (2008) Video & Handheld							
Weiquan Lu et al. (2014) Video & Handheld							
Kennedy et al. (2005) Video & Mirror							
Tillon et al. (2011) Video & Handheld							
Vlahakis et al. (2002) Optical & HMD							
Tanasi et al. (2012) Video & Handheld							
Thian (2012) Video & Handheld							
Lee et al. (2012) Video & Handheld							
Benko et al. (2004) Video & HandheldMD							
Chatzidimitris et al. (2013) Video & Handheld							
Keil et al. (2011) Video & Handheld							
Zoellner et al. (2008) Video & Handheld							
Madsen et al. (2012) Video & Handheld							
Damala et al. (2012) Optical & HMD							
Zöllner et al. (2009) Video & On Stand							
Herbst et al. (2008) Video & HMD							
Lochrie et al. (2013) Video & Handheld							
Coulton et al. (2014) Video & Handheld							
Čopič Pucihar et al. (2016) Video & Handheld							
Seo et al. (2010) Video & Handheld							
Kourouthanassis et al. (2015) Video & Handheld							
Cheok et al. (2002) Video & HMD							
Balduini et al. (2012) Video & Handheld							

(continued)

Table 1.3 (continued)

Valbuena (2010c) Spatial	■				High		
Valbuena (2010d) Spatial	■				High		
Valbuena (2010e) Spatial			■		High		
Valbuena (2013) Spatial	■				Moderate		
Valbuena (2014) Spatial	■				High		
Funk et al. (2017) Spatial			■		High		
Funk et al. (2017) Spatial			■		High		
Oosmo (2010) Video & Handheld	■				Moderate		
EYEJACK (2017) Video & Handheld	■				Moderate		
Scheible and Oiala (2009) Video & Handheld	■				Moderate		
Peddie (2017) Video & Handheld			■		Minimal		Moderate
MOSA (2016) Video & Handheld		■			Moderate		
Smau (2015) Optical & HMD		■		Moderate	Minimal		
Woiciechowski et al. (2004) Video & Mirror		■		Minimal	Minimal		
Yoon et al. (2018) Video & Mirror		■		Moderate	Minimal		High
Puspasari et al. (2019) Video & Handheld		■		Minimal			
Law (2018) Video & Handheld		■		Minimal			
Marques and Costello (2018) Video & Handheld		■		High	Moderate		
Fenu and Pittarello (2018) Video & Handheld		■		Moderate	Moderate		Minimal
Jade (2018) Optical & HMD			■	High	Moderate		
Trunfio et al. (2021) Video & HMD			■	High	Moderate		
Macleod (2012) Video & HMD	■				Moderate		Moderate
Blanco-Pons et al. (2019) Video & Handheld			■	High			
Marques (2021) Video & Handheld	■			High	Moderate		
Overly (2020) Video & Handheld	■			High			
Museum of London (2010) Video & Handheld			■	Moderate	Moderate		
Dow et al. (2005) Spatial & Handheld			■	Moderate	Moderate		
Wither et al. (2010) Video & Handheld			■	Moderate	Moderate		
Blum et al. (2012) Video & Handheld			■		Moderate		
Wagner et al. (2006) Video & Handheld		■		Moderate	Minimal		
ROM (2017) Video & Handheld		■		Moderate	High		
Kei et al. Video & Handheld	■			Minimal	High		
Baradaran (2011) Video & Handheld	■			Minimal	Moderate		
Scheible and Funk (2016) Video & Handheld			■				Moderate
Bruns et al. (2007) Video & Handheld			■	Moderate	Minimal		
Damala et al. (2008) Video & Handheld	■			Moderate	Minimal		
Yoon and Wang (2014) Video & Mirror			■	High			
Bimber et al. (2005) Spatial	■			Moderate	Moderate		
Tillon et al. (2010) Video & Handheld	■			Moderate	Moderate		Moderate
Aytekin and Kocak (2020) Video & Handheld		■		Minimal			
Hammady and Ma (2019) Optical & HMD		■		Moderate	Moderate		
Khan et al. (2021) Video & Handheld		■		Minimal			
Drift and Artsy (2017) Optical & HMD		■		Minimal	Moderate		
Hoagland (2019) Video & Handheld	■				Moderate		
Sari and Fajrin (2019) Video & Handheld		■		Moderate			
Chan and Ismail (2019) Video & Handheld		■		Moderate			
Ishida and Ito (2019) Video & Handheld			■	Moderate	Minimal		
Pollalis et al. (2017) Optical & HMD		■			Moderate		
Lidz (2016) Video & Handheld			■	High	Moderate		
Litvak and Kuflik (2020) Optical & HMD			■	Minimal			
Choudary et al. (2009) Video & Handheld			■	Moderate	Minimal		
Van Der Vaartet (2015) Video & Handheld			■	Moderate	Moderate		
Madsen et al. (2013) Video & Handheld			■	Minimal	Moderate		
Van Eck and Kallergi (2013) Video & Handheld			■	Moderate	Moderate		
Keil et al. (2014) Video & Handheld		■		Moderate	Moderate		
Nóbrega and Correia (2017) Video & Handheld					Moderate		Moderate
Kasapakis et al. (2016) Video & Handheld			■	Moderate			
Giannis et al. (2014) Video & Mirror			■	Moderate	Moderate		Minimal
Chalvatzaras et al. (2014) Video & Handheld			■	Moderate	Minimal		
Kenderdine et al. (2014) Video & Handheld			■	Moderate	Moderate		
Scopigno et al. (2015) Video & Handheld			■	Minimal	Minimal		
Pierdicca et al. (2015) Video & Handheld		■		Moderate	Minimal		
van Eck and Kolstee (2012) Video & Handheld	■			High	Moderate		
Ars Electronica F.lab (2009) Mirror & Handheld		■		High	High		
Harrington et al. (2019) Video & Handheld		■		High	Moderate		
Dang (2018) Video & Handheld		■		High	Moderate		
Ohlei et al. (2018) Video & Handheld		■		Moderate	Minimal		Minimal
Kyriakou and Hermon (2019) Video & HMD		■		Minimal	Minimal		
Hansen (2018) Optical & HMD		■		High	Moderate		
Hoagland (2018) Video & Handheld	■				Moderate		
Sugiura et al. (2019) Video & Hand. and Optical & HMD		■		Moderate			
Javornik et al. (2019) Video & Handheld			■	Moderate			
Impossible Things (2021) Video & Handheld	■				High		High
ViewAR (2021) Video & Handheld	■	■		Moderate			

A—Art gallery; **M**—Museum; **C**—Cultural Heritage Site; **a**—analytical activity; **s**—sensitive activity; **c**—communication activity; **p**—personalisation activity
Old reference; New reference
Minimal support Moderate support High support

and 1.6). Due to the subjective nature of results, we decided not to run statistical analysis on the gathered data, but instead focus on highlighting good practices from reviewed applications.

1.4.1 *Context of Use and AR Technology*

Results in Fig. 1.4 show that the majority (47%) of applications were deployed to cultural heritage sites. However, in recent years, there has been a slight increase of deployed systems to museums (the portion has increased from 22.9% in the 2004–2017 (early) period to 32.8% in the 2004–2021 (full) period), while the portion of AR applications used in cultural heritage sites decreased by 7.3%. Despite this decrease, AR applications deployed to cultural heritage sites still hold the largest share.

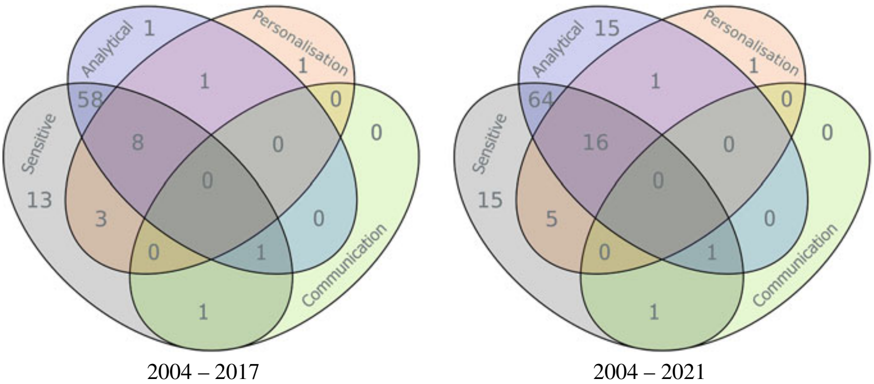

Fig. 1.3 Visualisation of classification based on AR taxonomy for art and cultural heritage in Table 1.3. Left graph shows data for the 2004–2017 period (early). Right graph shows data for the 2004–2021 period (full)

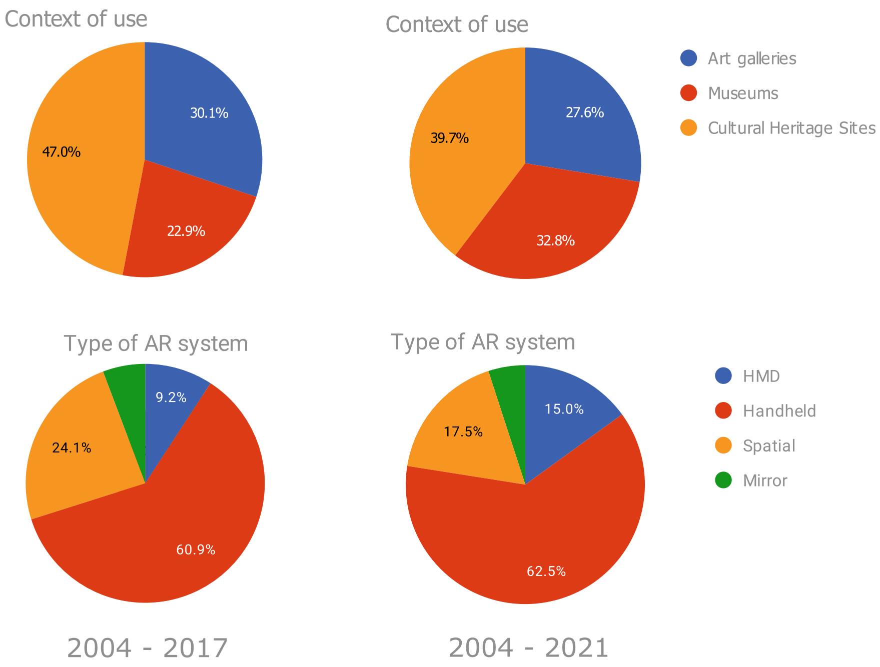

Fig. 1.4 Descriptive statistics: top row shows in what context most applications were used; bottom row shows what type of AR system has seen highest adoption; columns show data for different time periods

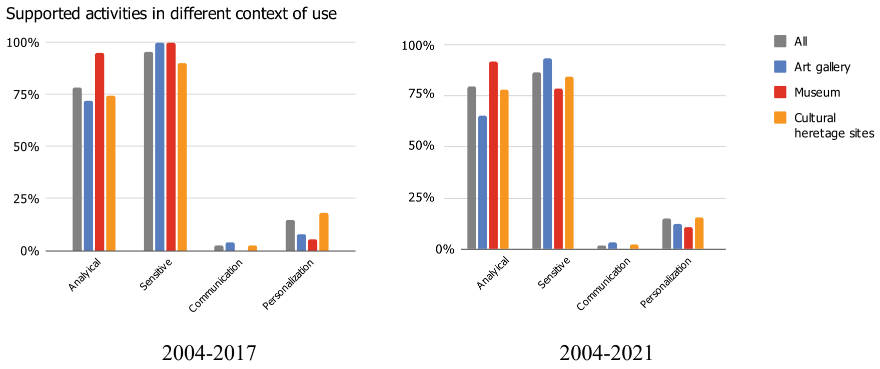

Fig. 1.5 Percentage of applications supporting individual activities of MAVM for different context of use for two different time periods—early and full

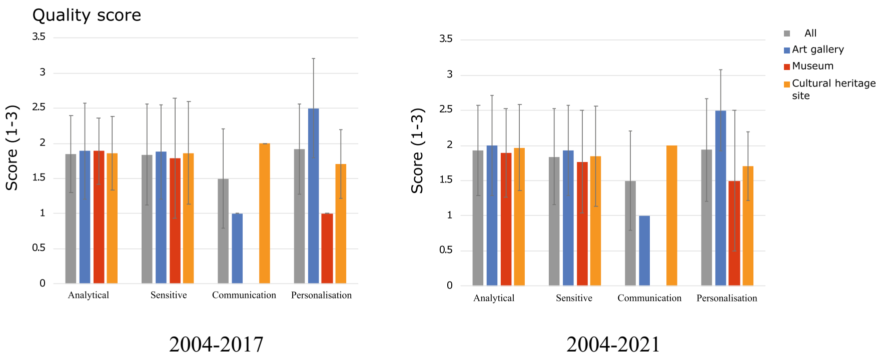

Fig. 1.6 Average support quality score for both time periods

Handheld AR is currently the most popular system used (61%). This result is not surprising since handheld AR applications are mobile solutions and are ideal when deploying technology to an outdoor setting (as is commonly the case in cultural heritage sites). Additionally, devices that are capable of running handheld AR applications are widely available, which further contributes to the popularity of handheld AR systems. However, handheld AR systems are faced with limitations in their ability to immerse the user into the augmented world.

From the perspective of MAVM, immersion is a very important element when considering sensitive activity. This is probably one of the key reasons for high percentage of spatial AR applications (24%), which can provide highly immersive experiences, but are plagued by the difficulty and cost of setting up as well as the limitation in regard to illumination levels (e.g. cannot work in brightly lit environments). We thus see these augmentations mainly as installations in art galleries (Valbuena 2014; Valbuena 2010c, 2010d, 2010e, 2013) and museums (Jean-Michel et al. 2011a, 2015c, 2015d, 2016a). Nonetheless, spatial augmentations of buildings and cultural heritage sites are also becoming more common (Funk et al. 2017; Jean-Michel et al. 2011c; Valbuena 2004, 2010a, 2010b).

However, in recent years, the number of spatial AR applications has decreased by 6.4%, which is likely the result of the availability of HMD technology with the off-the-shelf HMD AR devices (e.g. HoloLens, HoloLens2, Magic leap). Yet, it is important to note the adoption of these HMD technologies has largely stayed confined to the research community. Therefore, we have yet to experience the adoption of HMD within the museum settings at the scale of spatial and handheld AR systems. The HMD AR systems remain expensive, difficult to deploy and obtain outside of the research context. However, the immersive potential of HMD AR systems greatly surpasses that of handheld AR systems. As the technology progresses, miniaturises, and becomes readily available, these systems are likely to gain wider adoption.

In the case of mirror AR, users cannot interact with the world while looking into a mirror. Hence, the number of use cases where such setups make sense is small. This explains why mirror AR configurations are only marginally used. However, when such use cases can be foreseen, this metaphor can be very powerful.

1.4.2 Activity Support

The graph in Fig. 1.5 shows the percentage of applications that support an activity from MAVM. Theoretically, an ideal application would support all activities; however, this may not always be beneficial and might depend on the context or purpose of the application. Nonetheless, the results clearly show general lack of support for communication and personalisation activities across all contexts of use. This is the case for both time periods (early and full) and suggests that the adoption of AR technology in recent years did not manage to sufficiently progress in the direction of materialising its full potential. We believe there are many ways in which currently adopted technology could be utilised to support communication and personalisation activities. These will be presented in the following section where we discuss each supported activity individually.

The graph in Fig. 1.6 shows average quality score of activity support with standard deviation (note that only supported activities received a score from 1 to 3). Overall, (grey plot) all average scores are smaller than mid-score, (2) while communication activity scored lower than others. This suggests that on average, the quality of support for MAVM activities is low; hence, the technology adoption is not taking full advantage of technological development. Nevertheless, a slight increase in the quality score within the full period (2004–2021) can be observed, which suggests an improvement. However, based on a relatively high standard deviation, it is difficult to make any final conclusion. Nevertheless, the high standard deviation suggests there ought to be applications which do a good job in supporting MAVM activities. In the following sections, we thus highlight good examples selected from reviewed applications in Table 1.3.

1.4.3 Analytical Activity

Magnetic Maps (Yoon and Wang 2014) is a good example of supporting analytical activity, because it enables the user to experiment with invisible forces of magnetic field using a tangible interface with tactile feedback. This is achieved by augmenting real bar magnets that provide the interface for visualisation of the magnetic field. Even if the principle used in Magnetic Maps is not easily transferable to other situations, it demonstrates how learning by doing with AR can make for excellent support of analytical activity. It also highlights the importance of multimodality of the interface that actually enhances the quality of the experience.

House of Olbrich (Keil et al. 2011) is another example of good analytical support. The application enables the user to create a snapshot of the cultural heritage site (e.g. a building facade) from an arbitrary point of view and precisely overlays the captured image with additional information even in difficult outdoor lighting conditions. High precision of augmentation enables easy mapping of provided information to the real world. In addition, the application designers intentionally decided to overlay augmentations in a stylised form as sketches made by architects. This makes it easier for the user to grasp different facade features and highlights that realistic rendering is not something that should be pursued in all AR scenarios.

A more recent example is application Overly (2020), which is used by Latvian National Museum. The application enables visitors to gain additional insights about the painting beyond general information usually available in museums. The application enables users to select a part of the painting in order to extract further details about that particular area with the content that has been pre-annotated by museum experts. As Overly is a platform, it is relatively easy and cost-effective for the museums to deeply, yet as this platform supports only a limited set of functionalities, without the ability for expansions, it limits how the museum uses AR technology, the view we share with (Yılmaz and Apilioğulları 2021).

Another interesting application is Skin and Bones (Marques 2021), which is used in the Natural history museum in Washington D.C. This application is a good example of taking the full advantage of the rich space the museum offers. The application overlays bones and tissues over skeletons or places live animals besides stuffed ones. This excites visors and motivates them to engage further with the available content within the app and the museum per se.

1.4.4 Sensitive Activity

Holoman by Ars Electronica Futurelab (Ars Electronica Futurelab 2009) is an example of an application supporting analytical as well as sensitive activity. Holoman enables the user to hold a mirror in hand and explore the internal working of their body. As user do not see the reflection of themselves as such, but only a heavily mediated representation of the body, any errors in the alignment of the augmentation are unlikely to break the illusion of looking inside their own body. This in turn creates better immersion contributing to analytical and sensitive experience.

In (Weiquan et al. 2014), the artists created animations instead of text descriptions of their paintings in order to help visitors in analytical and sensitive deduction of artworks. These animations are then overlaid over paintings in the gallery when pointed at using a handheld device. The results show that this type of learning is effective and highlight the importance of high-quality augmentations, which were in this example done by the artists in the style of the painting itself. The latter is particularly important in supporting sensitive activity.

In ARART (Kei et al. 2012), the application brings famous paintings to life through animation. By controlling the lighting in the exhibition space and by creating high-quality animations tuned to the lighting condition of the exhibition, the authors managed to achieve excellent mixing of animated content with the environment offering good support for sensitive activity. This example also highlights how important the quality of augmentation is, particularly for sensitive activity.

A similar application to ARART is Reblink, which is used in the Art Gallery of Ontario, Toronto. It gives life to their art pieces, which can move in 3D, change their posture, and even enable the user to take come together with them in the painting. The application not only supports the sensitive activity, but through taking and sharing photographs, it supports the communication and personalisation activities we further discuss in the following sections.

1.4.5 Communication

Except for Reblink, none of the reviewed applications demonstrated good support for the communication activity. Hence, we see this as a great opportunity that has been overlooked so far by institutions running art galleries, museums, and cultural heritage sites. The communication activity is becoming ever more important for the tech-savvy society as more and more people readily record and share their everyday experiences. Therefore, the aforementioned institutions should focus on finding the right way to integrate social networking sites into AR applications while exploiting AR communication potential (e.g. context-aware bookmarking, sharing the visit experience of "I was here", support artistic expression by enabling curation of augmentation for exhibited artefacts).

1.4.6 Personalisation

From reviewed applications, there are two examples of our previous work that offer the personalisation potential. Taking artwork home is a handheld AR application that focuses on supporting personalisation activity (Coulton et al. 2014) by enabling users to curate personal art exhibitions in their home by replacing existing paintings with the ones provided by the Peter Scott Gallery (Lancaster, UK). The exhibitions are shared with other users of the platform also providing a sort of communication channel through user-curated exhibitions.

Playing with the artworks (Pucihar et al. 2016) is another prototype supporting personalisation activity by enabling gallery visitors to curate personalised versions of the exhibited artworks by colouring printed puzzles, which are used to generate a texture map of a 3D sculpture or 2D painting. This enables personalised interaction with exhibited artefacts and also creates a sort of communication channel by sharing the curated content with the museum and other visitors. This type of personalisation was also supported by Reblink, which enabled visitors to take their picture with characters portrayed.

Despite uncovering some examples of personalisation, there is a general lack in supporting personalisation. Together with communication activity, personalisation provides an untapped potential and opportunity for art and cultural heritage institutions to further explore and exploit to their advantage.

1.5 Conclusions

The goal of this chapter is to gain an insight into the adoption of AR in art and cultural heritage to reflect on future opportunities or highlight the missed ones. In pursuit of this goal, we propose an activity-based taxonomy model, which can be used to gain an insight in adoption of arbitrary technology and is based on formulating activity model for the context of technology use.

We utilised the activity-based taxonomy to generate AR taxonomy for art and cultural heritage. The context of technology use in our case is the activity of visiting a museum, art gallery, or cultural heritage site. In this process, we proposed an expanded Model of Activity of Visiting a Museum, art gallery, or cultural heritage site (MAVM) originally proposed by Tillon et al. (2011). Using the proposed AR taxonomy for art and cultural heritage, we classified 119 relevant AR applications and gained the following insights into technology adoption: (i) general lack of support for communication and personalisation activities persist; (ii) the quality of adoption remains below the satisfying level, yet some improvements have been made within the past few years; (iii) despite limited immersion capacity, handheld AR systems persist to be the most commonly used systems; and (iv) irrespective of difficult and costly setups, a substantial proportion of systems is spatial AR systems, yet this ratio recently dropped due to higher adoption of head-mounted display systems, but still largely limited to the research domain.

To sum up, the proposed activity-based taxonomy model generated a meaningful AR taxonomy for art and cultural heritage. The results of calcifications provided insights into technology adoption highlighting prominent avenues for future improvements.

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