

Exploring the Design of Hybrid Interfaces for Augmented Posters in Public Spaces

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ABSTRACT

The use of Augmented Reality for overlaying visual information on print media like street posters has become widespread over the last few years. While this user interface metaphor represents an instance of cross-media information spaces the specific context of its use has not yet been carefully studied, resulting in productions generally relying on trial-and-error approaches. In this paper, we explicitly consider mobile contexts in the consumption of augmented print media. We explore the design space of hybrid user interfaces for augmented posters and describe different case studies to validate our approach. Outcomes of this work inform the design of future interfaces for publicly accessible augmented print media in mobile contexts.

Author Keywords

augmented reality; poster; print media; cross-media; hybrid user interface; mobile physical interaction; public displays

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design; Experimentation; Human Factors

INTRODUCTION

Today, nomadic users are able to retrieve context-sensitive information through a multitude of interconnected digital artifacts such as location-aware handheld devices, public displays, and smart physical objects. While we are still operating in a physical world, an increasing amount of digital information is linked to print media, using technology like QR codes creating an information bridge.

Visually augmented print media, based on Augmented Reality (AR) technology is a recent rapidly rising example of this type of cross-media information space [34]. Mobile AR generally comes under the form of dedicated smartphone applications or as layer of information on mobile AR browsers such as Layar [21].

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Figure 1: Augmented Reality view of a mobile game. How to maintain the user experience when users move away from the poster?

Computer vision based approaches allow physical posters to both act as a physical hyperlink (or gateway) to digital media and as reference frame in which to visualize this content. In contrast to applications using the poster solely as physical hyperlink (such as Google Goggles [9]), AR applications require the users to explicitly stay in the vicinity of the physical object during the whole time of interaction. By not doing so, the experience vanishes. Indeed, current AR applications neglect that interaction with print media in public spaces often arises in opportunistic situations e.g., waiting at a public transportation stop [36].

We argue that similar to the creation of mobile multimodal systems [22] consideration of mobile contexts and the specific characteristics of handheld AR should guide the creation of interfaces for augmented print media deployed in public spaces. Within this paper we focus on those user interfaces, looking especially at printed posters: eye-level mounted printed papers that can be attached to planar (most often vertical) surfaces and consisting of graphics and text.

We conducted an online survey about information access on event posters to identify opportunistic situations in which users interact with posters and the actions that they conduct. We analyzed augmented print media experiences and structured the design space for hybrid interfaces for these experiences. Furthermore, we derived recommendations to guide the instantiation a specific hybrid interface design and applied it in two case studies. In these case studies the augmented experiences exhibit varying degrees of visual

integration between real and virtual elements. Our findings have relevance for the design of a broad variety of augmented print media experience, beyond posters, such as magazines or flyers that are consumed in mobile contexts.

RELATED WORK

Interaction with posters through mobile user interfaces has been considered mainly from two viewpoints. The first utilizes posters as physical hyperlinks to related information through tags (e.g., NFC or visual tags like QR codes) [3] or recognition of the poster itself through computer vision approaches [9]. The second utilizes mobile AR or personal projection systems to display the information on the physical object itself e.g., using a magic lens metaphor [1]. With this metaphor operated in a mobile context (as opposed to optical see-through solutions) the physical surrounding is *represented* in the interface; namely through a rendering of the built-in camera view on the environment.

Hybrid Interfaces through the combination of AR with alternative interfaces have been already considered over 10 years ago by Billingham et al. [2]. Their MagicBook combined illustrations in a real book with AR and immersive Virtual Reality views. Preceding work of Feiner et al. coined the term hybrid interface to combine different Virtual Reality and desktop devices in one physical reference space [6]. Later the notion of *transitional interfaces*, that allows fluidly changing between interfaces, was generalized [10]. Recent examples of transitional interfaces include zooming interfaces for AR Browsers [26] and view transitioning for distributed outdoor cameras [37]. An overview of combinations of AR with complementary interfaces (like maps, world in miniature, distorted camera views and virtual environments) can be found in [11]. The common theme of many existing hybrid and transitional interfaces is that they are grounded in one (eventually large and distributed) physical reference frame. We understand a *hybrid user interface* as one that offers *different representations of the physical reference frame* without the need to be located in that space, i.e. allow for the presence and absence of it.

User Adoption of novel digital information sources in mobile contexts such as location based services [38], physical hyperlinks (e.g., QR codes [5]), or digital signage systems [4][18] was investigated by academia and industry. Especially, interaction with public displays has been explored (e.g., [30]). The evaluation of AR in mobile contexts has gained attention only recently. For example Morrison et al. conducted field trials on the collaborative use of handheld AR using multiple mobile devices [25] and found that the interface imposes certain bodily configurations of groups around the maps. The adoption of mobile AR browsers has been investigated via online surveys [13][28]. Results indicate that AR browsers are still mainly used due to their novelty value and that user experience is still hampered by missing content.

Finally, the notion of *context* has been considered from diverse viewpoints including ubiquitous computing and the social sciences [5]. In computer science the measurability and predictability of context was pursued for years (and still is) and context was often only considered as part of the mobile work environment. Alternative approaches to understand social and interactional processes that form context in everyday life are considered in computer science only since a few years [36].

INFORMATION ACCESS AT EVENT POSTERS

We conducted an online survey about information access at printed event posters. It is based on situations in which users would interact with (potentially augmented) posters. Our survey is used to inform scenarios and guide the exploration of the hybrid interface design space and not to deliver representative study of user behavior at posters.

Survey

Thirty one participants (21 males, 10 females, age: M: 28.5 years, SD: 6.03) participated in the online survey, which was advertised via social network sites and e-mail. Their professional backgrounds were mainly in IT and design professions.

Most of the participants indicated to pay attention to event posters when waiting at public transportation stops (90%), at events like concerts (70%), followed by looking at posters in shops or bars (65%) and while walking through the city (56%). The majority of the participants (85%) stated that the name of the performers of an event should sound interesting (83% for event title) to engage further with the information on the poster. When participants decided to engage with a poster they did so for short durations (5-12 seconds 35%, 15-30 seconds: 48%). Asked about the type of information users try to remember, save or bookmark if they are interested in an event, 58% indicated to almost always remember the names of performing artists followed by the name of the event (48%), the venue (48%), and date (45%). However, 15% also pointed out to never or almost never remember the date. 65% specified that they would rarely remember website links. Habits of saving information for later reference included memorizing it (78%) taking pictures of the poster with their smartphone (33%) or scanning QR codes (13%). Other means for bookmarking were not used by the majority of the participants. While 50% of the participants access the information regularly when back home, 28% also access them through their smartphone on the move. Asked about which digital information they would like to access on an event poster participants mentioned ticket availability and prices (30%) as well as information about the event location (30%). Further information about the performing acts in form of multimedia content was pointed out by 45%. Only 15% explicitly mentioned means to bookmark the event and getting information about related events.

Discussion

Our survey partially confirms previous findings [33] about usage patterns at posters. Users typically engage with posters in opportunistic situations and only for a short time. Regarding access to further information, a third of the participants already used their smartphone to either bookmark an event (by taking a picture) or browsing further information while away from the poster. The observations indicate a current gap between the goal of extending the duration people spent with products or advertisements addressed through rich, interactive augmented print media experiences and the reality in which these interactions take place (namely in mobile contexts). A key insight from this survey - and previous research [36] - is that access of augmented print media in opportunistic situations should allow continuing the experience when moving on. However, this is still not considered widely when designing those type of user experiences. To address this gap we propose a novel type of hybrid interface to support exploration of digital content on augmented posters both on (poster) location and on the go.

HYBRID INTERFACE FOR AUGMENTED PRINT MEDIA

Interfaces for physical hyperlinks use real-world objects (or attached tags) to retrieve media through URIs (or search queries). For example, a growing number of newspapers equipped with QR codes allow downloading further media (such as videos) related to articles. As the initial retrieval of media typically only takes a few seconds (get out the phone, start app, scan) these interfaces can be employed in various mobile contexts that are characterized by multitasking, frequent changes of secondary user goals and chances of interruptions [32][36]. Information browsing on the go is enabled by displaying solely the retrieved content (e.g., on a mobile website). The physical object used as gateway to the information is not represented in the interface after the initial information access phase. In fact, no assumption is made about the spatial relatedness between the physical object and the linked content.

However, this spatial relatedness between physical and digital parts is a core characteristic of AR which can enable rich and engaging user experiences. In handheld AR systems this relationship manifests itself both in the realistic *representation of the physical surrounding* in the interface (rendering of the camera view) and the *physical navigation* (spatial gestures and postures) in that space. In contrast to geolocation based AR (using GPS and orientation sensors) the spatial extend of the reference frame provided by print media is very limited. The user experience of systems using only AR interfaces is tightly bound to this physical reference frame in which the user can be localized. The main question that we therefore try to address through the exploration of the design space of augmented posters is:

How to maintain the user experience initiated at an augmented poster if users move away from it?

To address this question we structured the design space as follows:

- Frame of reference of the poster
- Navigation of the information space
- Transition between interaction spaces

Frame of Reference

In common video see-through AR systems (such as employed on handheld devices) users perceive the physical environment in two ways. First, users are embedded physically in the environment and perceive it through all their senses. Second, they perceive a visual but *digital representation* of that environment on their handheld device. The camera stream is capturing the environment with a different field of view and resolution than the human eye and is rendered as background in the interface. It is this digital representation to which additional content is added. Through these two components users perceive the augmented “reality”. In fact other interfaces such as digital maps or even list views as employed in AR browsers also use (more and more abstract) representations of the physical environment (satellite views, distance and heading information).

While the physical context is lost when moving away from the print medium one can utilize its digital representation to keep up the parts of the original reference frame in a virtual space that are also used to display the added content (i.e. the poster itself without the environment in which it was mounted) (see Figure 2). Mapping the extend of the real medium on its virtual representation and resembling the real camera characteristics (foremost the field of view) in a virtual allows to keep the spatial relationship (position and sizes) consistent between the reference frame and the augmented items.

To create a digital representation of arbitrary physical environments that can be both viewed and interacted with can become a very challenging task as the scene has to be represented from arbitrary viewpoints. This involves creating a (concrete or abstract) 3D model of the physical scene or at least capturing it from representative viewpoints [8]. However, in contrast to arbitrarily augmented objects, print media consists (in many cases) of one or more layers of graphical and textual content and has nowadays most often already a digital representation (pictorial or vectorial) that finally gets physically instantiated during the printing process.

Our first design recommendation is therefore: *Preserve the frame of reference through a digital representation that encompasses the core parts of the physical environment.*

Navigation of Information Space

AR navigation in the reference frame is generally done in 6 degrees of freedom (DOFs – translation + rotation around x, y, z axis) and accomplished through physical interaction (moving around). It's thus mainly constrained by the users' movement relative to the physical print medium.

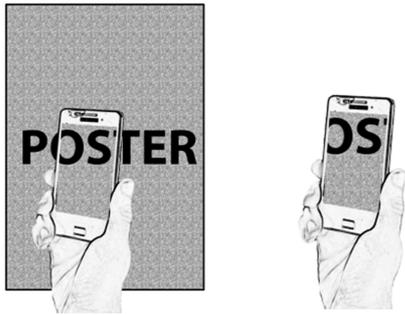


Figure 2: The representation of a physical print medium can be preserved by turning it into a digital surface.

To support the continuous interaction on-the-go, we must ensure that users can navigate and manipulate the digital representation of the physical object while they are standing away from the printed media.

On mobile devices 3d navigation and object manipulation is a non-trivial task. While there are approaches for both navigation (e.g., [41]) and manipulation (e.g., [16]) many assume some kind of constraint, like application scenario [29] or physical plausible behavior of the virtual environment [16]. Others are not validated in mobile contexts [41]. In contrast multitouch rotate-scale-translate (RST) techniques have become ubiquitous on small (and large) screen mobile devices and are at the hands of millions of users.

Which degrees of freedom can be constrained in the virtual view is dependent on the spatial complexity of the digital content and the supported tasks [35].

If the digital content integrated on augmented print media is of two-dimensional form (as is the case for the majority of available content in the internet available in mobile AR Browsers [13]) or can be interacted with from a frontal point of view the virtual camera position can be constrained to be perpendicular to the digital representation of the print medium. In turn, the navigation in the virtual space can be constrained to 4 DOFs (translation along x, y, and z axes). Now RST techniques can easily be used. Furthermore, when exploring multipage print media one can utilize surface gestures like flicking to resemble the turn over of physical magazine pages, as done with content aggregation services like Flipboard [7] for handheld devices.

If the digital content is spatially more complex, specific navigation techniques like the ones described in [17] can be integrated. For example, instead of supporting full 6 DOF navigation of elaborate 3D city scenes in virtual space constrained navigation techniques can be applied to ease the navigation task [24][29]. However, to the best of our knowledge there are no widely adopted techniques for navigating and manipulating in general 3D environments for mobile devices, yet.



Figure 3: To watch the augmented video users are forced to keep the physical magazine in view [42].

Furthermore, most current augmented poster experiences only employ simple object selection and manipulation techniques. We therefore suggest employing RST techniques and simple touching for object interaction.

So our second design recommendation is: *favor ease of navigation over complete navigability of the virtual space.*

Transition between Interaction Spaces

An alternative interface for an augmented print medium is not only beneficial if the user moves away but it can also support the exploration of media items when still in the physically vicinity of the printed object. For example, as the viewpoint in a handheld AR interface is directly controlled via the movement of the users' arms and hands in a metric space fatigue might result over time. This fatigue can be pronounced if the user is forced to hold the phone in one position over an extended period of time. A common real-world example (as of April 2012) is watching an embedded video on a poster or magazine (see Figure 3) which only appears if the print medium is in the view of the camera. Enabling the consumption of the video while still providing the reference to the print medium in virtual space could result to significant fatigue.

However, offering different interaction spaces such as AR and a pure virtual representation can be challenging as users need to map the context of interaction when transitioning between them [10] (foremost the viewpoint and the control mapping for navigation). For example, if one restricts the possible viewpoints in the virtual space to be perpendicular to the print medium the user has to mentally overcome the gap between the position of physical camera relative to the real print medium and the position of the virtual camera relative to the virtual representation of the print medium. To lower the cognitive effort of mapping of points from one space to the other view transitioning techniques can be employed [37] [26].

Consequently, our third design recommendation is: *Minimize the cognitive effort when transitioning between interaction spaces.*

CASE STUDIES

Using our design space we propose a hybrid interface for augmented posters. We introduce the hybrid interface for two case studies, featuring differing degrees of visual integration between real and virtual poster elements. While both case studies employ vertically mounted posters, similar hybrid interfaces can also be used in other physical configuration of print media.

Hybrid Interface: Augmented Reality + Zoomable View

Our hybrid interface consists of an AR component and a zoomable view component of the print media.

The *AR view* represents the environment in the interface through a live camera view and allows navigation of the information space through movements of the handheld device.

In the *zoomable view* the physical reference frame is represented by a 2D rendering of the print media. In contrast to previous approaches [15][23] the whole information space is interactive and navigable through pan and zoom capabilities (drag and pinch gestures) following the static peephole metaphor [40].

As the relative positions of the digital media elements w.r.t. the printed medium do not change (whether it is now represented physically or digitally) the mental effort needed to map points from the augmented physical space into the virtual space is eased.

The *transition between both components* can be initiated in two ways. Firstly, users can point their phone away from the printed media and will get an orthogonal overview of the whole poster (or page of a magazine). If the user has to unexpectedly leave the implicit change to the virtual view allows her to continue the content exploration later on. Figure 4 depicts the example of a vertically mounted poster but the transition could easily be applied to horizontal media like magazines as well. Furthermore, this behavior can be triggered if the tracking of the print medium is failing (see [39] for further examples of dealing with tracking failures). Secondly, users can trigger a transition from the current physical camera viewpoint to the closest orthogonal virtual camera viewpoint explicitly. This behavior is useful when an information item is accessed in the Augmented Reality view and should be further explored in a less straining pose (e.g., triggering the playback of a video which is then consumed in a relaxing pose). We allow to transit back and forth between the spaces and, in contrast to previous approaches [20] [44], do not impose a virtual interface when the user is still at the augmented object.

In the following we introduce our two case studies using this interface: Event Poster and Game Poster.

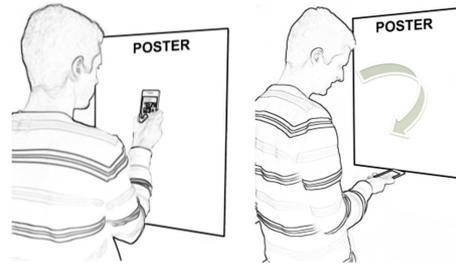


Figure 4: Transition from AR into zoomable view by pointing the phone away from a poster.

Both prototypes were developed for android smartphones (we used a Samsung Galaxy SII) employing a natural feature tracking system and running at approximately 30 frames per second.

Case Study I: Event Poster

In a first case study we describe a design of an augmented poster in an information browsing task on street posters. It encompasses an augmented poster that could today be created by publicly available tools such as Layar Creator [21] or semantic authoring tools [12].

The Prototype

The integration between real and virtual elements on AR poster reflects what a designer can achieve without the need for collaboration with a 2D graphics designer, a 3D artist or a programmer. Specifically, we did not include any 3D models but rather traditional media items that are readily available on Internet. In our prototype, we added simple widgets (Facebook, calendar, regions to toggle the visibility of other media items) that could be included in manifold print media independent of the actual content. For the poster theme we chose a local rock band of Graz, Austria. The digital content was retrieved over YouTube and from the website of the band. The augmentation poster (size DIN A0) is illustrated in Figure 5 (left). The transition between the AR and the zoomable 2D view could be achieved through two techniques. First, an explicit transition from AR to zoomable view can be initiated by a vertical bezel swipe [31] thus “freezing” the current view. This technique can be used when still at the poster location when users want to explore information items and not necessarily need pointing at the poster. An implicit transition between the two views is initiated by pointing the phone upwards (enabling the AR view) or downwards (enabling the zoomable view). When switching from AR to zoomable view by pointing downwards an animation is transforming the last known position of the camera to a default overview showing the whole virtual poster. The video and the Facebook widget only appeared after touching circular trigger regions that could help to temporarily reduce visual clutter on posters with high item density.

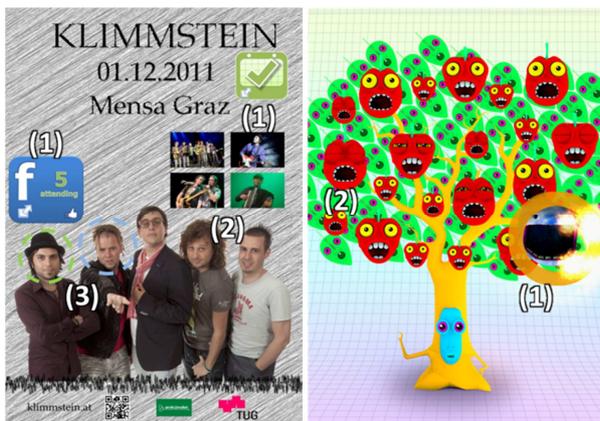


Figure 5: Posters with depicted digital content. Left: event poster with 2D media items like widgets (1), image collection (2), trigger regions for showing / hiding content (3) and videos (not visible). Right: game poster with 3D (1) and 2D (2) animations.

Initial User Feedback

A formative evaluation gave us first insights into how users would handle the hybrid interface in the presence of low visual integration between real and virtual objects. We deliberately evaluated this prototype in the lab without considering the mobile context to concentrate on usability aspects of the hybrid interface [19].

To test our prototype we conducted the evaluation with 9 participants (age: M: 25.5 years, SD: 5.6, 4 female, 5 male, 2 with background in AR, the others having not interacted with AR interfaces before) recruited from on campus. The experiment was conducted inside an office of our institute in which the poster was mounted at eye level. Participants were video-recorded and asked to think aloud. They were informed about the scenario of exploring related digital media connected to an event. A learning phase at a different poster should make participants familiar with the interaction techniques. In the running phase, users were asked to explore the poster (shown in Figure 5 left) as long as they wish and think aloud. This part was of exploratory nature to observe how participants would interact with the different information items on the poster. Participants received no instructions on how or which information items they should access.

Interaction in Augmented Reality and Zoomable View:

While users were asked to start exploring the information in the mode of their liking, seven out of nine participants started to explore the poster with the AR view. They preferred walking up to the widgets and triggering the action (“add entry”, “like”) by tapping as one participant stated “it’s nice to get the information at the touch of a button”. These seven participants also initiated the video playback in the AR view but eventually switched to the zoomable view with one saying “If I want to watch things for an extended period of time in this (AR) mode it feels just a little uncomfortable”. Others also mentioned that they

would prefer the zoomable view for detailed information exploration with one participant mentioning: “Just walking up and clicking on things is really easy, but if I want to watch something in more detail I like go to this (zoomable) mode”. While walking up to the display and pointing on items was found easy one participant also preferred the zoomable view “as I do not want to walk up to the poster all the time”. One user explicitly disliked the AR view mentioning privacy issues and stating “I am afraid that others might see what I see when holding up the phone. I like to watch the information on my own”.

Transition between Views: Being able to switch between AR and zoomable view was generally appreciated by the participants. The surface swipe for changing from AR into zoomable interface was most often used when viewing the video and initiated with the index finger of the dominant hand. A user stated that “it feels nice to capture it (the video item) right where you are”. However, not all participants made use of this technique, rather zooming in from the default 2D overview after moving the phone downwards with one mentioning difficulties in conducting the swipe gesture. The animation transforming the egocentric into an exocentric view in this interface was not considered to be necessary by participants. We also observed that three participants tried to pinch and drag on the phone’s display while in AR mode.

Discussion

The evaluation focused on gathering initial feedback about the combination of AR and zoomable interface when accessing digital media embedded on a physical poster. Explorative in nature it indicates that participants made use of both views depending on the media type. They preferred to watch the video in a comfortable pose enabled by the zoomable view and exploring information items like widgets with simple functionality directly at the poster.

However, animated transitions from the AR to the closest orthogonal 2D view or the overview was not considered necessary. We thus omitted the animated transitions in the later prototype as this study indicated. On the contrary, visual similarities between AR and virtual representation might even be too high. This might be explained by the visually similar representation of the printed and the virtual poster in contrast to the visually demanding changes when switching from a live into a map view [26].

Case Study II: Game Poster

The second case study employs the same hybrid interface in a game poster setting. In contrast to the low visual integration between real and virtual elements of the previously described prototype we focused here on achieving a tight coupling between printed poster and digital game elements. For this prototype, we collaborated with programmers, 3d artists and graphic designers.

Game Design

The game was a point and click type of game (find-and-select task) including background music, audio and graphical effects. The game was built on an augmented poster (size DIN A0) showing an illustration of an apple tree. The apple icons printed on the poster in Figure 5 (right) were replaced by animated faces that were making grimaces at different speeds. Animated and growling 3D worms were coming out of the apples' mouths (20 possible locations, 2 sizes) and had to be hit by tapping them three times. Each level lasted approximately one minute, we had 8 levels. The levels did not increase in difficulty, only the positions and sizes of the worms were varied randomly. The game could be played in the AR (see Figure 1) and in the zoomable interface (see Figure 6). Instead of using the bezel swipe gesture we included simple buttons at the bottom of the screen to allow for faster explicit switching between the views. Users could explicitly switch between the interfaces by pressing buttons at the bottom of the screen which would show the closest orthogonal view of the virtual poster when switching from ML to SP. When users pointed their phone down they implicitly switched into a standard view (showing approximately 2/3 of the virtual poster). Through pre-experiments we adopted parameters for dragging and pinching speeds, the default scale for the virtual poster and minimum distance for target selection to ensure comparable times in both interfaces for a trained user.

Study

The study took place in three different settings, in a laboratory, at a public transit place and at a conference in the field of Augmented Reality. Insights specific to usage patterns in a public setting are described in [14]. In total 22 participants (8 in the lab, 8 in the public, 6 in the conference setting) aged between 21 and 48 participated (10 female, 12 male) took part in the study. They were either holding a university degree or being still at the university. Participants conducted the study in front of the poster mounted vertically at a height of 2 m. They were videotaped and notes were taken by the experimenter. We discuss next pooled observations over all three locations relevant to the design of the hybrid interface.

Interaction in Augmented Reality and Zoomable View

Similar to the first case study most participants (20) started to interact in the AR view and continued to use it throughout the game. This was done by many despite arising fatigue effects like shaking arm and hands (6 participants) or changing the way the phone was held (12 participants).

Participants mentioned the Augmented Reality view being “more fun”, “novel” or “more intuitive”. One participant explicitly mentioned that “I would probably not use it if it would be commonly available”.

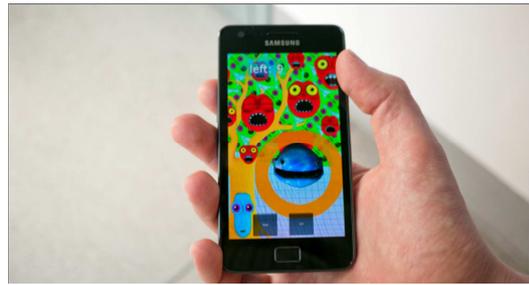


Figure 6: The virtual representation of the AR view in Fig. 1.

They used the zoomable view in case the tracking system failed temporarily (7 participants), as overview to find the next target (by pointing the phone down) and because it felt more comfortable for them (3 participants). Another participant used the zoomable map view exclusively as it was “not as shaky” as the AR view.

As the study still was taking place in constructed settings (participants knowing that they were taking part in the study and being observed) participants were encouraged to think about the usage of the system in real-life contexts. They explicitly liked the idea of taking the game with them to continue to use the game e.g. “in a café”. Playing with friends around was mentioned explicitly by two participants as well as using it “as alternative to internet browsing at a bus stop”.

Discussion

Despite factors such as arising fatigue most participants used the AR interface. However, there were also participants who eventually switched into the zoomable view who combined both interfaces in unique ways (overview + detail). Furthermore, some causes for switching between interfaces could not reliably be identified. For example it was hard to distinguish if users switch from AR to 2D mode due to fatigue or due to failures of the tracking system which could be a confounding factor in the study [27]. While it might seem obvious that the overwhelming use of the AR view could be due to the novelty factor this circumstance should be explored further.

DISCUSSION AND RECOMMENDATIONS

The usually limited timeframe for accessing information at posters in mobile contexts requires interfaces that do not end the user experience when users leave the physical vicinity of the object. They should allow retrieving and initially exploring the most relevant information quickly directly at the physical print medium and enable further interaction with the information also if that print medium is absent. We initially addressed the missing support for continuing augmented poster experiences in mobile contexts through the exploration of the design space of hybrid interfaces. While we implemented and initially tested our design concepts they have to be further formally evaluated under real-world conditions.

We presented two instances of augmented posters that employed a frontal view and did not allow for complex 3D scene navigation. As described before offering full 6 DOF interaction in the virtual space is neither trivial nor always desirable [35]. Depending on the complexity and type of 3D content that is augmented on the poster one could integrate recent mobile device specific navigation techniques such as [17].

The recommendations we can give from our explorations are: 1. Allow users to explore information while away from the augmented media. To support this preserve the frame of reference of the printed media. 2. If you employ complex 3D scenes think carefully what kind of interactions you want to support in an alternative view. Favor ease of navigation over complete navigability 3. Minimize cognitive effort when transitioning between interaction spaces. While in our case studies transitioning between the augmented poster view and the virtual view was possible without view transitioning techniques they might be beneficial for more complex 3D scenes. Similar think about when to support implicit interface changes. For example one could automatically initiate a view transition for time consuming media items such as videos.

CONCLUSION

We explored the design space of hybrid interfaces for augmented posters considering mobile users' contexts and the characteristics of Augmented Reality. Instead of providing solutions that will work for every augmented print medium we combined Augmented Reality and zoomable interfaces that will work for many. We initially evaluated the concept of hybrid interfaces in two case studies and while the Augmented Reality view was used most of the time the zoomable view was used in situ as well, especially if using the Augmented Reality mode became too tiring.

In future work we will address the applicability of the current concept to more complex 3D scenes and verify its usefulness in more diverse mobile contexts. This especially includes distributing the interface through advertising campaigns and collect data on the system usage remotely.

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