Taking the ‘A’ Out of ‘AR’: Play Based Low Fidelity Contextual Prototyping of Mobile Augmented Reality

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Abstract
“Taking the ‘A’ out of ‘AR’” means implementing the augmented elements of an interface and contextual elements of reality in a more controlled context to allow for proof of concept evaluations. This paper proposes a prototyping technique that bridges the gap between traditional paper prototyping methods used for interface design and evaluation, and the challenges associated with the development of visual, context-aware augmented reality (AR) applications. An initial evaluation of this technique was conducted through the examination of a small-scale case study of user evaluation sessions of a mobile application.

Author Keywords
Augmented reality; mobile augmented reality; prototyping; user testing; play based testing; user centred design.

ACM Classification Keywords
• Human-centered computing → Mixed / augmented reality • Human-centered computing → Gestural input • Human-centered computing → Systems and tools for interaction design • Human-centered computing → Walkthrough evaluations.

Introduction

With the increase in demand for AR experiences, it can be easy to prioritise development and delivery over concept design and user evaluation. There are a variety of approaches being taken to tackle the issue of evaluating AR concepts and interaction methods, but many rely on high fidelity prototypes being created before evaluation steps can take place [4][11]. Low fidelity prototyping is a more sensible tool for concept and basic interaction evaluations [2], but the lack of complexity poses a difficult question: How can the complexities of AR technologies, such as contextual markers and interactions, be accurately implemented within a low fidelity tool? This paper posits a solution to this problem, synthesising the augmented elements of an interface and contextual elements of reality to allow for proof of concept evaluations, within the context of a small-scale pilot study of a visual context based mobile AR application [13]. We will discuss the key concepts of augmented reality and prototyping approaches, outline our methodology for designing and evaluating the prototyping approach, and then present the outcomes of the initial application of the technique.

Augmented Reality and Prototyping

The augmentation of the real world with virtual elements is a variation of mixed reality known as augmented reality, or AR [1]. These technologies can come in a variety of formats, from direct and indirect [15] to visual, auditory, and haptic augmentations [12]. A key tenet of augmented reality is the embedding of digital elements into the real world, which, for mobile AR, tends to rely on contextual (usually visual) markers. This need for contextual markers can make it difficult to evaluate the user experience in detail, as the context may be difficult to replicate on a consistent basis.

Recently, with the release of Pokémon GO! [5], the awareness and popularity of AR technologies has increased amongst the general population, despite the tendency for users to disable the visual AR mode in favour of the static interface [8]. The increase in awareness and popularity of these technologies has boosted the need for an efficient and effective method for prototyping and evaluation, and while teams are beginning to put forward approaches, a comprehensive solution has yet to emerge.

One of the main characteristics that distinguishes one prototyping approach from another is fidelity. High-fidelity prototypes can provide a true-to-life replication of an experience for evaluation, but they also require a large upfront investment of time and effort [10]. Low-fidelity prototypes lack some of the complexity and accuracy of their high-fidelity counterparts, but this is made up in the minimal upfront investment and ease of alteration [10]. Conducting early-stage user evaluations can be beneficial for the user experience of the final product [6], and low-fidelity prototypes are better suited to this approach thanks to their flexibility and low initial investment. Existing low-fidelity prototyping methodologies are now beginning to be adapted to the requirements of AR, to varying levels of success.

Prototyping around contextual markers

Lauber, Böttcher, and Butz [7] proposed PapAR, a methodology for prototyping AR interfaces for car-based HMDs. The PapAR team modified the more traditional paper prototyping methodology to incorporate two layers of ‘paper’: the underlying layer,

Figure 1: The proposed interface for the "Flick to Kick" mechanism. Players flick the ball element (bottom centre) towards goal posts seen in the camera feed. A camera button (bottom right) allowed players to screenshot personal highlights. [13]

which featured a sketch or image of the environment in which the interface was to be implemented; and the top, transparent layer, with the dimensions of the possible active display area marked out in red pen. This system meant UI elements could be drawn into the environment, and the display area could be shifted around the driver's field of view to determine the optimal positioning of the interface.

Other teams have also developed solutions to address the issue of contextual markers in prototyping. Chen and Zhang [3] established a contextual evaluation system that utilised paper prototypes, Google Hangouts, and Google Glass that allowed participants to interact with a paper prototype on a mobile device in the contextual location, while also giving designers the opportunity to modify the design in real time as the testing session progressed. The application relied heavily on location markers rather than visual contextual markers, but it did also evaluate the user interaction mechanisms within the context of use.

Previously, research teams have proposed a variety of solutions which addressed issues including technology restrictions [7][14] and contextual limitations [3][7]. However, their treatment of contextual markers didn't meet the need for a quick, simple implementation of the contextual elements in a way that could be produced in a user research lab, and still be interacted with as if they were real, with the same level of fun and interactivity. While PapAR [7] utilised traditional paper prototyping methodologies in a visual AR context, it lacked the contextual engagement of placing users in an actual car. Chen and Zhang's work [3], while both dynamic and low-fidelity, was replicating location-based AR rather than contextual visual overlays. Techniques for utilising traditional paper prototyping to replicate visual AR that relies on visual contextual markers are yet to be fully investigated.

Context

In order to explore paper prototyping with contextual markers, a small-scale pilot of the low-fidelity play-based prototyping method was developed. However, it is made up of several generalizable components that could then be adapted to other contexts. This particular study was designed to evaluate a game concept situated within a mobile AR application intended for implementation at live sporting events [13], without any access to the venue where the application would be implemented. "Flick to Kick" was a mini-game that allowed attendees at National Rugby League (NRL) games to compete against each other, scoring points by 'flicking' virtual footballs through the field's goal posts from their seat in the stadium, as seen in Figure 1. The flicking mechanism draws on a familiar quick swipe up gesture and concept used in popular games like Paper Toss [9] and Pokémon GO! [5], but introduces an augmented reality element by utilising the actual goal posts on the field within the stadium as a visual context marker and the target.

Designing a Method for Prototyping

Our approach was motivated by a need for a low-fidelity prototype evaluation method that included elements to contextualise the mobile AR experience that were dynamic, rather than static, and ideally replicated the playfulness, delight, and physical engagement of the intended functionality. The key difference was that part of the application functionality relied on virtual interaction with the contextual marker (the goalposts), and so to create a low fidelity paper prototype that still replicated the functionality of an AR interface, the contextual marker would need to be recreated physically as well. Recreating the contextual marker within a traditional paper prototype similar to PapAR [7] would be simpler and quicker to develop, however it would lack the physical and dynamic interactivity of a small-scale replication. In this context, it was necessary for participants to be able to engage with the marker on a variety of angles, and adjust these angles as they saw fit, which would be difficult to replicate with a 2D drawing of the contextual marker.

The contextual marker could have been 'accessed' by conducting testing sessions within the intended application environment (a sporting stadium). However, it was more desirable to explore options that could be executed within a user testing lab, which would allow for a more convenient, controllable, and replicable solution. Replication of the context at a lab scale was better for establishing testing sessions, but it required the physical scale of the marker to be reduced. This meant it was possible to replicate some of the less realistic physics components of the game, namely being able to flick a ball up to 100m away, without putting strain on the participants, or needing to further distance the activity from the 'flick' metaphor.

Figure 2: The testing materials before being set up, showing the goalposts (left) and the phone model (bottom right).

The Prototyping Method

Creating the Prototyping Materials

There were 3 key components that needed to be translated into the low fidelity prototype to accurately reflect the core game mechanics and restrictions: the device, the contextual marker, and the virtual element(s). Within the context of mobile AR at live sporting events, this meant the team needed to replicate the phone, the goal posts, and the ball in a way that participants could recognise and interact with which simulated the application metaphor.

To do this we 3D printed a model of a generic mobile phone handset. The model was modified by cutting a rectangular hole all the way through where the display would be, allowing users to see the view that would be displayed if the phone showed a direct camera feed. A small tee that protruded from the bottom of the hole for balls to rest on was also added to guide the placement of the ball, matching the default position of the ball element in UI designs as seen in Figure 1. Replicating the posts and ball was much easier, as pieces of wooden dowel were glued together to form a scaled down version of an NRL goal post (two vertical poles connected by a crossbar), and pieces of paper were scrunched up to be used as footballs. Originally, the team sourced a collection of small rubber footballs to be used during the tests, but a pilot test with team members revealed these balls had the potential to hurt when flicked, and so they were replaced with paper balls. The translation of both contextual and virtual elements into the real lab environment removes the sense of digital augmentation provided by AR applications, leaving only the elements within reality, which is where the phrase "Taking the 'A' out of 'AR'" stems from.

Executing the Prototype

The application and evaluation of the prototyping method took place in user testing sessions that were set up to evaluate the whole mobile application functionality. A total of 9 participants (both university staff and students) participated in individual 1-hour testing sessions which consisted of an introduction, a self-guided exploration and discussion of application

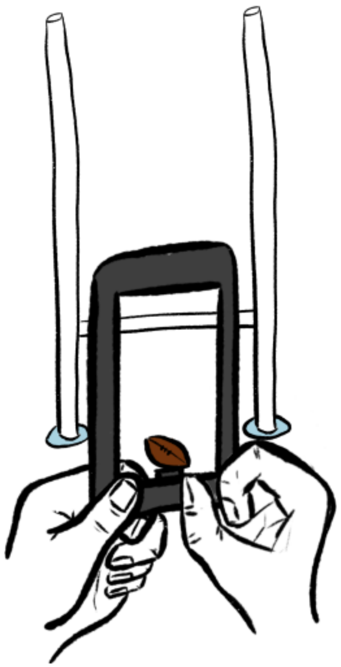

Figure 3: A sketch of the prototype interaction from the perspective of the participant. The participant holds a 3D printed model of a mobile phone handset and attempts to flick a ball through the goalposts.

screenshots, a task-based evaluation, and the "Taking the 'A' out of 'AR'" activity.

The prototype was set up within the research lab on a table, as shown in Figure 2. When it came to complete the "Taking the 'A' out of 'AR'" activity, the goalposts were moved to an upright position in the centre of the table. Participants were free to interact with the prototype for as long as they felt engaged and were able to use the phone model and paper balls in any way they saw fit. The observer instructed participants to play how they thought the game mechanism would work, based only on the game set up, the screenshot of the proposed interface, and the knowledge that the game was called "Flick to Kick". During the activity, participants were also encouraged to explore the physical space around the goal model, using positive prompts such as "that's great, why don't you give it a go from the other side of the table?".

During this time, the observer noted the participant's interpretation of the game mechanism, their engagement with the activity as a game, and their engagement with the prototype as a low-fidelity presentation of a potential AR application. These observations served as the evaluative data for the prototype testing methodology, as engagement and functionality interpretation were the two primary success criteria for the technique evaluation.

Outcomes

Observations recorded during the session indicated that all participants enjoyed the activity to some extent. While about a third of the participants were hesitant or disinterested in the activity to begin with, many participants ended up standing for the majority of the activity, being actively engaged in approaching the challenge from different angles and trying different techniques to flick the ball between the goalposts. The primary technique that all participants adopted, either for part or all of the activity, was to line up their shot at the goal posts, balance a ball on the phone tee, and then flick the ball off the tee towards the goals, as illustrated in Figure 3.

Two participants attempted to use the touch interface style flick gesture, but (correctly) acknowledged that this technique was unlikely to see them successfully score a goal. They made a few more attempts with this gesture before adopting the more traditional flick for "better aim". A few participants chose to abandon the phone model altogether, instead relying on their other hand as a balance point for the ball, however this could be attributed to the difficulty of balancing the irregularly shaped paper ball on the tee, an issue that would not be present in the actual application. One participant, who had a sporting background, even attempted to kick the paper ball through the goalposts as one would a regular football, with limited success. While the majority of participants did indicate they enjoy the activity, many also indicated they were frustrated, through various sighs, groans, and comments such as "Oh no!". While this could be interpreted as an indication of frustration with the testing activity, participants' continued engagement and cheers when they were successful were a reasonable indication that the responses were more of a visceral reaction to the challenge of the game mechanism.

In terms of using the low-fidelity prototype as a parallel for a mobile augmented reality application, only 2 participants specifically commented on the parallels between existing AR functionalities, such as Pokémon GO!, during the activity. However, 7 of the 9 participants had, when shown the interface design in Figure 1 for an earlier activity, correctly assumed and understood the 'flick' gesture required to interact with the game. While participant responses do raise a concern that the activity is still too conceptually distant from a mobile AR experience to accurately assess the feasibility of the game mechanics and interaction techniques, this could be attributed to the ordering of the activities in the broader testing setup. It is possible that participants did not feel it was necessary to reiterate their understanding of the mechanism, as they adopted the physical flick gesture and understood the goal of the game without discussion.

Conclusions

It is recommended that future research is conducted to explore the minimum required characteristics for a low-fidelity prototype for users to maintain a connection to the concept of AR. Furthermore, an investigation should be conducted into the benefits and drawbacks of this paper-based methodology when directly compared to low- to medium-fidelity functional prototypes. To address the issue concerning translation of the physical metaphor to the touch gesture, more testing could be conducted that incorporated a final activity that explicitly asked participants to indicate on a flat paper prototype or mock screen design the gesture that they would use to replicate the interaction. This would provide more concrete evidence to clarify whether the physical metaphor is too detached from the touch gesture system to serve as a user testing mechanism. It could also be incorporated as a part of the evaluation technique, to gather data on the participants' expected or intuitive interactions with the touch interface based on the physical metaphor.

Having utilised this prototyping method in a small-scale user evaluation, we can say that it has potential as a beneficial tool in contexts where low-fidelity prototyping is necessary but access to contextual markers is limited. However, there were also indications that more refinement is required to create a truly replicative low-fidelity prototype that allows users to engage with the experience more accurately.

Currently, this technique has potential to be a methodology used in circumstances where low-fidelity paper prototyping is necessary, and the application being designed is reliant on interactions with a visual contextual marker. This should be restricted to circumstances where the game mechanism relies on physics and physical constraints that can be reasonably replicated in a user testing laboratory. Specifically, this paper proposes a technique that bridges the gap between traditional paper prototyping methods used for interface design and evaluation, and the challenges associated with the development of visual, context-aware augmented reality applications.

References

[1] Azuma, R.T. 1997. A Survey of Augmented Reality. *Presence*. 6, 4 (1997), 355–385.

[2] Buchenau, M. and Suri, J.F. 2000. Experience prototyping. *Proceedings of the conference on Designing interactive systems processes, practices, methods, and techniques - DIS '00*. (2000), 424–433. DOI:https://doi.org/10.1145/347642.347802.

[3] Chen, K. and Zhang, H. 2015. Remote Paper Prototype Testing. *Proceedings of the ACM CHI'15 Conference on Human Factors in Computing*

Systems. 1, (2015), 77–80. DOI:https://doi.org/10.1145/2702123.2702423.

[4] Delabrida, S., D'Angelo, T. and Oliveira, R.A.R. 2015. Fast prototyping of an AR HUD based on google cardboard API. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers - UbiComp '15*. (2015), 1303–1306. DOI:https://doi.org/10.1145/2800835.2807928.

[5] Homepage | Pokémon Go: 2016. *http://www.pokemongo.com/en-au/*. Accessed: 2017-08-16.

[6] Kujala, S. and Mäntylä, M. 2000. Is user involvement harmful or useful in the early stages of product development? *CHI '00 extended abstracts on Human factors in computer systems - CHI '00* (2000), 285.

[7] Lauber, F., Böttcher, C. and Butz, A. 2014. PapAR. *Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications - AutomotiveUI '14*. (2014), 1–6. DOI:https://doi.org/10.1145/2667239.2667271.

[8] Paavilainen, J., Korhonen, H., Alha, K., Stenros, J., Koskinen, E. and Mayra, F. 2017. The Pokémon GO Experience. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17* (2017), 2493–2498.

[9] Paper Toss: 2018. *https://play.google.com/store/apps/details?id=com.bfs.papertoss&hl=en*. Accessed: 2018-03-13.

[10] Rudd, J., Stern, K. and Isensee, S. 1996. Low vs. high-fidelity prototyping debate. *interactions*. 3, 1, January (1996), 76–85.

[11] De Sá, M. and Churchill, E. 2012. Mobile augmented reality. *Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services* (2012), 221–230.

[12] Schraffenberger, H. and van der Heide, E. 2016. Multimodal augmented reality: the norm rather than the exception. *Proceedings of the 2016 workshop on Multimodal Virtual and Augmented Reality - MVAR '16*. (2016), 1–6. DOI:https://doi.org/10.1145/3001959.3001960.

[13] Thompson, A. and Potter, L.E. 2017. Proposing Augmentation of Live Sporting Events with Gamification and Social Sharing. *29th Australian Conference on Human-Computer Interaction* (Brisbane, QLD, Australia, 2017), 5.

[14] Wiethoff, A., Schneider, H., Küfner, J., Rohs, M., Butz, A. and Greenberg, S. 2013. Paperbox – A toolkit for exploring tangible interaction on interactive surfaces. *Proceedings of the 9th ACM Conference on Creativity & Cognition - C&C '13*. (2013), 64–73. DOI:https://doi.org/10.1145/2466627.2466635.

[15] Wither, J., Tsai, Y.T. and Azuma, R. 2011. Indirect augmented reality. *Computers and Graphics (Pergamon)*. 35, 4 (2011), 810–822. DOI:https://doi.org/10.1016/j.cag.2011.04.010.