

Through the Looking Glass

Mobile Interactions for Augmented Space



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*“Well! I’ve often seen a cat without a grin; but a grin without a cat!
It’s the most curious thing I ever saw in my life!”*

– Alice in Wonderland, Lewis Carroll

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Mobile Interactions for Augmented Space

At the intersection of physical and digital space is **mobile augmented reality (AR)**, a new medium with its own rules that need to be explored. AR is much more than a tool to locate the nearest cash machine or play with a virtual toy. It is pure magic; a blend of the mind's eye and our natural sight (and don't forget artificial intelligence). And, while not without its challenges – both technologically and socially – AR presents a valuable new way of thinking for artists, designers, and architects alike. AR was once the fiction of *Minority Report* and Phillip K Dick novels. Now it is absolutely within our grasp. Using a compass here and a camera there, and a little GPS for good measure, city streets become a stage for storytelling and creativity.

On-the-go learning, spontaneous gameplay, and personalized portable guides; all of this is possible today. Up until now, AR reports have focused largely on technical implementation and one-off experiments. As the field evolves, so too must the design strategies. With this in mind, we present to you **a compendium of interaction design concepts and tools for augmenting space**. We hope it will provide a strong starting point and provoke further thought on creating meaningful augmented experiences.

Movement & Wayfinding

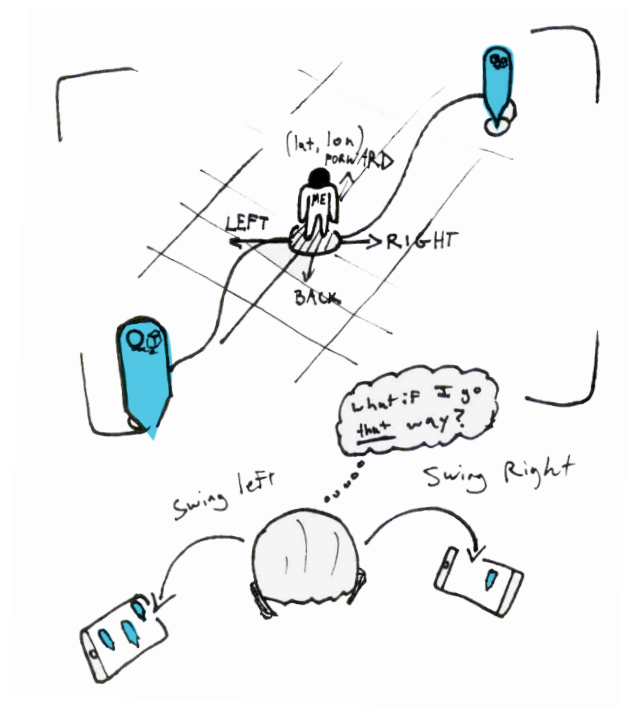
Our augmented world calls for dynamic navigation systems that respond to usage context. This section provides techniques to support movement and exploration for location-based games and tours.

Turn-by-turn Walking

We have turn-by-turn driving in our cars and Google Street View. Augmented reality can provide a guideline beneath your feet, connecting you with your destination. Boston's Freedom Trail tour follows a painted red line through the streets¹. With AR **the trail adapts to your needs**. Point your phone's camera towards your feet and find your guideline. Choose from a variety of colored paths. Virtual arrows on the ground indicate the direction to walk and alert you to upcoming landmarks and rewards. Lines can appear and fade based on player behavior.



¹ "Freedom Trail". Wikipedia. 17 Jul 2009. <http://commons.wikimedia.org/wiki/Freedom_Trail>



Signposts On Demand

The signpost is a universal tool of the traveler pointing the way to city centers, landmarks, and items of interest. In the wilderness? Just look at the sky. The stars and sun that moon came first. The mobile screen provides virtual signposts which can be called up anywhere and everywhere. Simply hold up your screen and **reveal paths on-the-go**². Use the arrow keys on your phone to preview a destination. The signpost translates to your language and responds to your interests; maybe it remembers you by name. Take care, though, as location data is not always available or accurate on mobile devices.

X-Ray Vision

Big rock in your path? When sight fails you x-ray vision is just a pocket away. With the right map data your phone can **see behind walls** (and rocks) and help you on your way. Reveal enemy players hiding behind the door or a secret passage beneath the floor panels. How might x-ray vision create new layers of narrative in an otherwise ordinary space?

***TIP** Where are you going and where have you been? Good navigation design will reveal the right path while always offering a safe way back home. When available, use a compass, tilt sensor, or GPS to help orient the player. Consider modes of transport, real-world obstacles, and physical handicaps in your design — understanding movement and timing is key to a successful augmented experience.*

² A similar concept is demonstrated here:
 "Real-time Panorama Mapping and Tracking on Phones". Christian Doppler Laboratory. 11 Nov 2009.
http://studierstube.icg.tu-graz.ac.at/handheld_ar/wwwsignpost.php



Radar Map

Lost without a map? Radar tells you where to go. AR objects and destinations may be indicated by an overlay with a variety of shapes and colors. The player remains at the center of the radar screen, with objects fading in when the player moves to within a certain proximity. Radar indicates **orientation relative to a game world** (or real world). The radar map is already available in Layar, Wikitude, WorldSurfer, and other mobile AR browsers. Video games like Quake and World of Warcraft use radar maps to guide players in the heat of battle or on an epic quest. A “fog of war” may be used to obscure parts of the map which have not yet been explored.



Geo-Buttons

For games and tours you may want to deliver media or rewards based on player location. Spots on the map can be plotted as **triggers for interactions**. When a user reaches a certain location he automatically “pushes” a geo-button. Just like a physical button, the geo-button is an indicator of user intent and therefore should be clearly marked to prevent accidental activation — unless, of course, it is used more like a tripwire or land mine. When designing geo-buttons we must consider the accuracy of geo-positioning (GPS vs. cell phone triangulation vs. WIFI hotspots) and the movement speed of the user, as both affect how “big” a geo-button should be in order to be “pushed” easily. Gates, closing hours, and traffic can impede physical access to a geo-button, so make sure to play test your geo-buttons at various times of day.



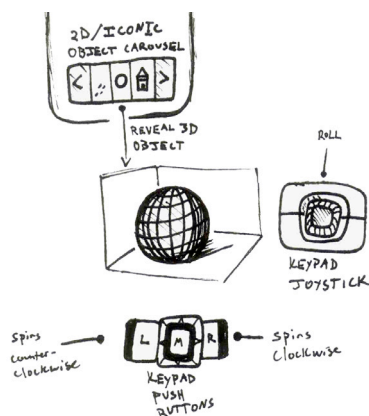
Media & Surfaces

Virtual and real landscapes unite. This section introduces techniques to view and manipulate 3D AR objects.

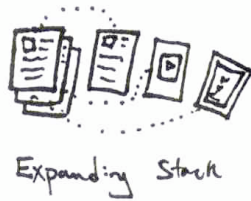
Inspector Gadget



AR objects deserve close inspection. Think of character designers for video games or the modeling tools in 3D software. After discovering an AR object, 3D or flat, you can pull up an Object Inspector for more details. In addition to an information layer with title and description, the Inspector should include tools to **rotate, zoom, and pan**. If available, 4-way navigation on a phone’s joystick is ideal. Press the center button to cycle between the Rotate, Zoom, and Pan tools, then use the left, right, up and down keys to manipulate the object. Details of an AR object should scale based on device specific performance metrics of CPU, memory, and graphics.

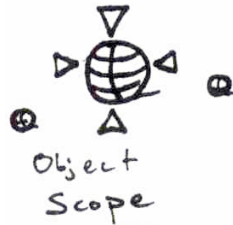


Stacks & Stacks



Stacks allow you to publish digital media on walls, in rooms, and in the streets. A stack may contain any number of web pages, documents, videos, and 3D objects, grouped together in a common AR scene. Hold your camera over a stack for a few seconds, and the **media scatters outward like a herd of wild bison**. Now pan your camera across the scene until you find what you need. Open web pages in the mobile browser and 3D objects in the Object Inspector to zoom, pan, and rotate. How about a collaborative stack? Have a class collect photos of birds from the park, then stack them up to form a location-based public archive available to any passer-by. This interaction is inspired by the Apple Dock and Bumptop stacks³

Hide & Seek



Think of the Object Scope as a metal detector for game objects. Where's Waldo? As you pan your phone left to right, up and down, **the scope's triangles guide you to the closest AR object**; vibration can be used in concert to indicate whether you're getting hotter or colder. If an object is off-screen to your upper left, the scope arrows will gather at the top-left of the screen to lead the way. As you swing closer to your target, the arrows gather around to form a perfect sniper's scope. Now, pause for a second while pointing at an object and the Object Scope may optionally "lock on" to show relevant details. From here you can release the scope with one button (right keypad button) or open the object in the inspector with another (left keypad button). In busy scenes with multiple game objects, the Object Scope becomes a valuable guide and input device.

TIP As mobile hardware gets boosted we will be able to offer realistic 3D objects and scenes on-screen, but should a game world ever look like the real thing? Check out the immersive fallacy (Rules of Play, Salen and Zimmerman) and Kevin Slavin's thoughts on the 'uncanny valley' (<http://bit.ly/augmentedcity>).

³ "Bumptop 3D desktop enhancement". <<http://bumptop.com>>

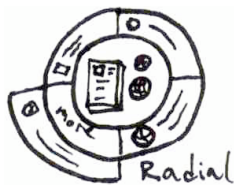


Dial-An-Object



Lots of objects to choose from? Use 360 rotation to select from nearby objects. A half sun-dial design, oriented around the bottom-center of the mobile phone screen, can help. Turn to your left and the dial spins right accordingly, bringing into view new objects and aligning your spatial perception with the designed AR world. Using the compass, the phone only displays those objects that are available in the direction you are facing. Keep the horizon in mind when designing an AR experience. What does the user see, not only nearby, but out in the distance?

The Radial Reveal



Picture a mobile game where players dig for buried treasure in the sand. You might find a chest of coins and jewels, and here you discover the Lost Codex of Atlantis. What's that, you say? The Codex can be "Opened", "Flipped Over", or "Torched"? Touch the Hourglass on your screen to bring up a radial menu of special abilities. What you have here is a way to **"pop open" an object and reveal its properties**, and maybe then to go a level deeper and "pop open" more levels of detail. Radial menus are notably used in Second Life, the Smalltalk programming interface, and the Songza.fm online music service.

Magic Markers



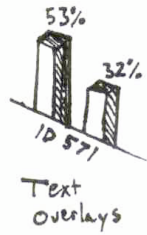
By aiming the camera at a visual marker such as the QR Code, the player automatically activates a desired digital behavior. Markers — also known as 2D barcodes, glyphs, or fiduciary markers — are often used to **overlay virtual objects on players and props** or to **call up online data**. They can be printed on posters, game costumes, and trading cards^{4 5} to facilitate AR experiences. Use this technique in good lighting conditions and print markers as large as possible to avoid scanning errors (see "AR Engines" below for technical implementations). "Markerless" image recognition can also be used to similar effect. For example, Google Goggles uses a massive image database to display search results for artworks and commercial products. More details on markerless can be found in the "Visual Search Tools" section below.

⁴ "QR-Kill. First Match in History". 23 Jan 2008. <<http://www.qrcode.es/?language=en&p=209>>

⁵ "QR code - Explore a whole new way to window shop, with Google and your mobile phone". 10 Dec 2009. <<http://www.arvertising.com/news/2009/12/qr-code-and-google/>>



Pop-Up Statistics



Cameras and 3D rendering **bring data visualization to new heights**. Have an object with some useful data stored within? Unlock its metrics on air quality, forces of gravity, or battery power by pointing your cameraphone that way ⁶. Think fuel gauges or electricity meters for everyday objects and places. This requires a QR Code or other marker, and the result is a fundamentally new way of thinking about the relationships between live data and physical things.

Tools & Techniques

Technically Speaking

In 2009, with the launch of the Layar augmented reality browser and increased coverage of MIT's "Sixth Sense", AR crossed a threshold between academic and popular culture ^{7 8}. But while advertising agencies flock towards AR as the "next big thing", the experts acknowledge there is a long way to go. Today augmented reality suffers from technological limitations in terms of motion tracking, plane detection, location data, image stabilization, and polygon rendering capacity. Mobile screens are a far cry from head-mounted displays in terms of display resolution and instantaneous access. Furthermore, access to AR services is limited to a select few with special hardware and software. All of this means that mobile AR interfaces will have trouble reaching mass adoption and providing a superior user experience, at least in the near term.

"The fact is the hardware just isn't accurate enough to deliver on the types of precise experiences that are being showcased and promised in videos around the net."

— We Are Organized Chaos, August '09

There is hope, however, that 2010 will bring massive improvements to the realm of mobile AR. The average hardware on mobile phones is improving, which means better graphics and sensor data, and platform developers are rapidly working to resolve technical limitations. Researchers and entrepreneurs have generated strong interest for AR products, and there is proven excitement surrounding the field ^{9 10}. AdWeek believes that mobile AR will have the greatest impact over the next 5-10 years, but cautions "it's not quite ready for prime time" ¹¹. It is, however, quite possible to design and prototype augmented reality experiences even today. The tools available are more powerful than ever, the hardware is more affordable, and, since the field is still evolving, there are numerous opportunities for innovation and experimentation.

6 "Pachube.com: augmented reality demo". 30 June 2009. <<http://www.youtube.com/watch?v=sxr8oaRUq6k>>

7 "TED: MIT Students Turn Internet Into a Sixth Human Sense". Wired. 5 Feb 2009.

<<http://www.wired.com/epicenter/2009/02/ted-digital-six>>

8 "Layar Puts the Reality in Augmented Reality". Cabana Mobile. 2 Nov 2009.

<<http://cabanamobile.blogspot.com/2009/11/layar-puts-reality-in-augmented-reality.html>>

9 "Tonchidot Madness: The Video". TechCrunch. 17 Sep 2008.

<<http://www.techcrunch.com/2008/09/17/tonchidot-madness-the-video/>>

10 "Two to Three Years: Simple Augmented Reality". 2010 Horizon Report. 14 Jan 2010.

<<http://wp.nmc.org/horizon2010/chapters/simple-augmented-reality/>>

11 "2010: The Year of Augmented Reality?" AdWeek. 28 Dec 2009.

<http://www.adweek.com/aw/content_display/community/columns/other-columns/e3i777feb08b28dccab97a386a2c25e48d5>



AR Engines

For those looking to create unique gaming or learning experiences, there are a range of open-source and commercial solutions available. AR engines such as ARToolkit, ARTag and Metaio Unifeye use computer vision to track markers, images, and textures and can output 2D and 3D graphics layered over the real world ¹². They provide easy access to functionality which is common to most AR experiences and take care of the low-level programming. For an open, modern AR engine we recommend StudiersTube ES (<http://bit.ly/arengine>), which provides a full framework for prototyping any sort of AR experience.



ARTag "Magic Lens" Systems <<http://www.artag.net>>



Map Tracking using an AR Engine
<http://studierstube.icg.tu-graz.ac.at/handheld_ar/videos.php>

Augmented Reality Browsers

AR browsers are mobile applications that overlay real-world panoramas with content listings from the Internet (e.g. Wikipedia, Twitter, restaurant directories). Browsers use a smart-phone's compass, GPS, and camera to determine user location. Such browsers often allow third-parties to write plug-ins that provide new layers of content without having to install a new application. At the time of writing, Layar is the leading AR platform with support for Google Android and iPhone. Other notable browsers include Wikitude, Cyclopedia, GeoVector's World Surfer, and Acrossair's "Nearest Tube".



Layar provides an open and rapidly growing platform to build AR experiences
<<http://layar.com>>

¹² "Top 10 Augmented Reality engines that will ignite a new era of video games". Games Alfresco. 13 May 2008.
<<http://gamesalfresco.com/2008/05/13/top-10-augmented-reality-engines-that-will-ignite-a-new-era-of-video-games>>





Cyclopedia overlays Wikipedia entries according to location and orientation
 <<http://www.chemicalwedding.tv/cyclopedia.html>>

Visual Search Tools

Google Goggles was released in late 2009, branded as a visual search and augmented reality tool. It works by matching the image from a camera viewfinder with an image database, then translating this into a Google search. Depending on the type of object, search results may contain reviews or purchase options. The idea of visual search is being explored on many levels – posed at times as a navigational tool, an add-on for social networking, or for media & entertainment – and by an assortment of companies and research labs. Apple recently applied for a patent discussing a mobile application that recognizes objects based on visuals (in concert with an RFID reader and GPS) ¹³. Nokia released an open platform named Point & Find, which includes a publishing platform to create branded experiences through “worlds” of digital content and services ¹⁴. These various tools, while centered today around consumer and culture objects today, will very likely expand to perform facial recognition, raising significant questions of privacy and identity.



Google Goggles can identify landmarks, artworks, and products
 <<http://www.google.com/mobile/goggles>>



MobVis Project explores artificial vision in smart mobile applications
 <<http://vicos.fri.uni-lj.si/projects/mobvis>>

¹³ “Apple Files for more iPhone Patents”. 10 Jul 2009. InformationWeek.
 <<http://www.informationweek.com/news/mobility/business/showArticle.jhtml?articleID=218401418>>
¹⁴ “Nokia Point & Find”. Nokia. <<http://pointandfind.nokia.com/>>



To Reveal The Invisible

AR is new and old and yet to come. 1965 brought a dream of “The Ultimate Display” but today all we have is the mobile phone. Whatever can be done? It turns out... a lot! In the previous pages we have outlined the state of mobile AR and proposed new interaction designs to support gameplay and learning. We have explored the major players in AR software and considered the limitations of today’s devices. The excitement around mobile AR guarantees continued evolution through 2010, while the field is still new enough to support radical innovation.

Thus far the standard approach for AR has been to layer virtual objects and surfaces over the real world, or to display contextual information about landmarks, streets, and products. In his prescient essay on the topic, Sutherland proposes that augmented vision “gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland”. Theorist Lev Manovich agrees with Sutherland, adding that “architects along with artists can take the next logical step to consider the ‘invisible’ space of electronic data flows as substance...”¹⁵. Perhaps, then, the true power of AR is not in world-building but in understanding our existing world; capturing the patterns and flow around us, the spectrum of life beyond our innate senses.

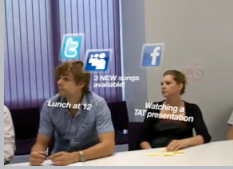
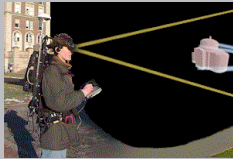
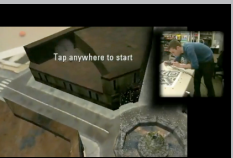
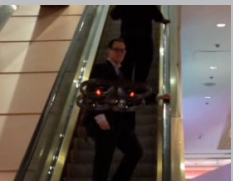
And what about games and learning? Already social media and location-based tools are converging on the mobile context, hinting at a new fabric of spontaneous, multi-person game experiences. These experiences will present significant design challenges and opportunities as friendship, status, and reputation are visualized in augmented space. What happens when our online and real-world identities collide? And without physical playing fields or goals – for indeed augmented experiences are only augmented for those with access – how do players and non-players interact? For answers, we need not look to theorists. Designers are rapidly creating new games and applications that test the boundaries of augmented space.

Names to Watch: *Area/Code*, *Come Out & Play*, *Foursquare*, *Nokia C3*, *SCVNGR*, *Conflux*, *Blast Theory*



¹⁵ Manovich, Lev. “The Poetics of Augmented Space”. p. 31

Notable Works

Preview	Description	Reference
	Integrating a real-world presentation with social media profiles and rating system.	Haliburton, James. "TAT Augmented ID". < http://mobileuserinterfaces.blogspot.com/2009/07/tat-augmented-id.html >
	A 1996 exploration combining mobile and augmented reality technologies. Projects include a touring guide, journalist workstation, and indoor/outdoor collaborative tool.	"MARS - Mobile Augmented Reality Systems". < http://graphics.cs.columbia.edu/projects/mars >
	A shooter combining table-top gaming, skittles, and high-quality mobile graphics.	"ARhrrr: An augmented reality shooter". < http://www.youtube.com/watch?v=cNu4CluFOcw >
	A video game combining augmented reality and a real, hovering UFO with camera attached.	"CES 2010: the 'most awesome' iPhone video game". < http://www.telegraph.co.uk/technology/ces/6939359/CES-2010-the-most-awesome-iPhone-video-game.html >



Suggested Readings

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