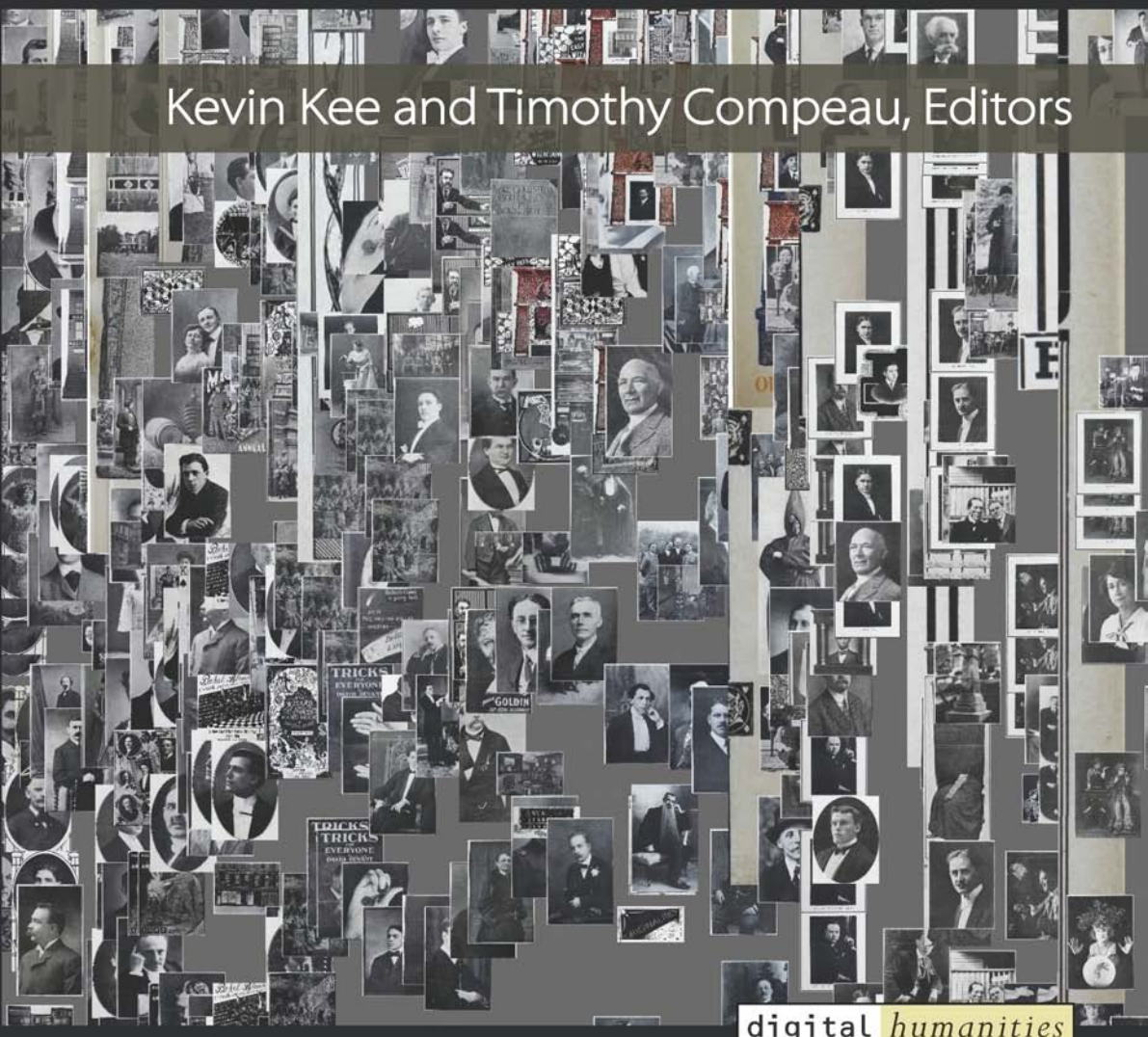
Seeing the Past with Computers

Experiments with Augmented Reality and Computer Vision for History

Kevin Kee and Timothy Compeau, Editors



digital humanities

Seeing the Past with Computers

Experiments with Augmented Reality and Computer Vision for History

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CHAPTER 12

Hearing the Past

Shawn Graham, Stuart Eve, Colleen Morgan,
and Alexis Pantos

In this final chapter, a group of archaeologists take us into the world of aural augmented reality, explaining how lost soundscapes can be rebuilt and the profound impact they can have on a visitor's connection with the past. This has been a book about seeing the past, but as the authors remind us, we can use more than sight to explore the past. Hearing past soundscapes can provide whole new ways of experiencing, understanding, and feeling history.

This volume is about seeing the past. But "to see" does not necessarily imply vision, for we frequently "see" things that do not exist. In this sense, to see something can also mean to understand it: "I see your point" or "I see what you're saying." How, then, should we "see" the past? We cannot see the past; we can only see the present. And even when we look at something "from" the past, it still lives in the here-and-now. Augmented reality (AR) can help us better mediate differences between the past and present, yet even though AR does not require vision, the majority of AR apps currently available privilege the visual, overlaying reconstructions or text on an image of the present through a keyhole—the viewport offered by our small screens. But here, too, the clumsiness of our interfaces, the clunky visual overlays, create a cognitive load, a "break in presence" that interrupts what we are seeing with awkward details, preventing us from seeing the past and understanding it in any meaningful way.[1] This is why we talk of the historical imagination, or the archeological eye.

We assume that the senses neatly cleave, allowing us to prioritize one

sense over another. With our contemporary focus on the visual, we tend to prioritize sight over other senses, but in this chapter, we suggest that "hearing" the past is a more effective and *affective* way of providing immersive AR.[2, 3] We argue from cognitive and perceptual grounds that audio—spoken word, soundscapes, acoustic horizons and spaces, and spatialized audio—should be a serious area of inquiry for historians exploring the possibilities of new media to create effective immersive AR. To do so, we explore some of the phenomenology of archaeological landscapes and the idea of an "embodied GIS" as a platform for delivering an acoustic AR.[4] Drawing on Phil Turner's work on "presence" in an artificial environment, we explore "breaks" in presence that occur in augmented, mixed, and virtual environments.[5] The key idea is that presence is created via a series of relationships between humans and objects, forming *affordances*; when these relationships are broken, presence and immersion are lost. Considering that the sense of hearing depends on attention, we argue that audio AR is particularly effective in *maintaining* what Turner calls "affective" and "cognitive/perceptual" intentionality. In short, the past can be "heard" more easily than it can be "seen."[6]However, hearing (and the active cognition that hearing requires) is an area that has not been studied to the same degree or in the same depth as the visual.[7] We first explore the ways in which hearing and listening affect us before turning to three case studies that offer possible routes forward for an augmented historical audio reality.

"Eh? Can You Speak Up?" The Sense of Hearing

Hearing—and understanding—can be considered a tactile, haptic experience. Sound waves actually touch us. They move the tiny hairs of the ear canal, and the tiny bones within, and the various structures of the middle and inner ear turn these into the electrochemical pulses that light up the various parts of our brain. Sound is a kind of tele-haptic:

> [T]he initial stage of hearing operates as a mechanical process. Later the mechanical energy of sound converts to hydraulic energy as the fluids play a larger vibratory role. Thus at its source, touch operates with and causes sound, and it is only through touch-at-a-distance that we have sound at all. The famous story of Edison's ears bleeding from his aural experiments makes visceral this tele-touch, which is not always a gentle stroke, no matter how pleasant the sounds, voice or music we might encounter.[8]

Bishop goes on to argue that while touch and vision are senses that can only know the surface, sound gives us access to that which is hidden. Sound waves permeate, transgress, and transcend surfaces; they cause surfaces to vibrate, to amplify, and to muffle. In so doing,

> Sound provides the means to access invisible, unseeable, untouchable interiors. If we consider the import of vision to the general sensorium [what we think of as the five senses] and metaphorization of knowledge, then the general figurative language of 'insight' runs counter to surface vs. deep understanding of the world. Sound, it would seem, not vision or touch, would lead us to the more desired deep understanding of an object or text.[9]

To demonstrate, Bishop points to Karlheinz Stockhausen's *Helicopter String Quartet* as a piece in which sound and touch blur (and "slur") into a kind of synesthesia, which defies the "assumed neatness of the sensorium."[10] Chris Godsen, in an introductory piece to an issue of *World Archaeology* on the senses in the past, argues that our Western "sensorium" influences and conditions how we understand material culture.[11] He advocates unlearning and unpacking the privileged position of sight, what others have called "ocularcentrism."[12]

The effect of structured sound (let us call it "music") on movement is another interesting area where the haptic qualities of sound may be perceived. Interestingly, there are aspects of music that seem to translate into movement "primitives." A recent study explored the relationship of musical structure (dynamic, harmony, timbre) to guided walking (mobile tours).[13] The authors note that a focus on structure in music sits between the thematic (where the emotional content of the music is manipulated) and the sonic (which is associated with spatial cues). Thus, they wondered what aspects of structure would be perceived by their nonmusically-trained study subjects (Western university undergraduates at an Anglophone university) and how the subjects would translate these into music. The subjects listened to four distinct compositions designed to emphasize one aspect of musical structure as they moved around an open field. The subjects were observed and afterward interviewed as to why they stopped, moved to particular areas, or moved in certain ways at particular moments during the music.

The authors found that participants interpreted silence in the music as a signal to stop, *crescendi* (a rising intensity in the music) as a sign to move forward, and *diminuendo* (a lessening intensity of the music) as an indication to end movement altogether. Meanwhile, musical punctuation prompted

listeners to try to understand the significance of the particular spot they were standing on, while timbre "colored" different areas; in other words "harmonic resolution" signaled "arrival."[14] As our case studies demonstrate, such interplay of silence and crescendo can be a powerful affective tool for conveying the density or paucity of historical information in an area.

Intentional hearing—that is to say, listening—also affects us in that it requires *attention*. In the crowded foyer of a cinema, for example, it can be quite difficult to make out what the person opposite is saying. We have to *pay attention*; the act is tiring, especially if we try to read lips, attempting to match visual cues with auditory cues. Similarly, in the quiet of a classroom, with their backs turned, teachers can hear the surreptitious whisper that, while much quieter than in the cinema foyer, speaks volumes. Hearing, unlike sight, requires *active* attention that divides our ability to make semantic or emotional sense of what is being said, or even to remember quite *what* was said, when the original audio signal is poor.[15] What is more, our brain is processing the spatial organization of the sound (near sounds, far sounds, sounds that move from left to right)—that is, *how* it is being said, not just *what* is being said.[16]

In brief, sound requires cognition to make sense; there is nothing "natural" about understanding the sounds that reach our ears, and this act of attentiveness can help elide other breaks in presence, making sound an integral component for understanding the past in the context of our world today.

Culture and Soundscape

"As a little red-headed Metis kid," Zoe Todd writes, "it never occurred to me that the city could sound different to anyone else."[17] Todd recently wrote a moving piece in *Spacing* entitled "Creating Citizen Spaces through Indigenous Soundscapes," in which she describes, among other things, the profound effect of a flash mob occupying the West Edmonton Mall's replica of *Santa Maria*, Columbus' flagship: "The sounds of Indigenous music, language and drumming soaring high up into the mall's glass ceiling was a revelation: decolonization of our cities is not merely a physical endeavor, but also an aural one."[18]

Soundscapes affect us profoundly, and as Todd demonstrates, they can be used to radically reprogram, repatriate, decolonize, and contest spaces. Work on the cognitive basis of memory has shown that, rather than being like a filing cabinet from which we retrieve a memory, the act of recollec-

tion actively rewrites the memory in the present, making our memories as much about our present selves as they are about the past. Thus, cognitive scientists working in the field of posttraumatic stress disorder are finding that they can reprogram the emotional content of traumatic memories by altering the contexts within which those memories are recalled, and sound plays a critical role in such work, literally rewiring our brains and our understanding of memory.[19]

The work of cognitive scientists, plus Tim Ingold's observations about the "meshworks" of interrelationships that create spaces and bind them in time,[20] prompts questions about the ways sound might help us access and work with the past: can soundscapes help us "visualize" the past, or at least bring to the surface different patterns in the meshwork? Can we reprogram collective memories of place with sound?

Such questions have been explored by a number of scholars, particularly archeologists in the field of archeoacoustics. Most work on archeoacoustics has explored the properties of enclosed spaces such as caves, theaters, and churches.[21] In particular, Mlekuz has investigated the soundscape of church bells in an area of Slovenia. He takes Schafer's definition of the soundscape: whereas an acoustic space is the profile of the sound over a landscape, the soundscape is a sonic environment—with the emphasis on the way it is perceived and understood by the listener.[22] This clear distinction between the mechanics and properties of the sound (the acoustic nature) with the effect it has on the listener (the soundscape) fits perfectly with Turner's idea of the "arc of intentionality." Where we may be able to recreate the sounds of the historical past, we may not be able to recreate how these sounds came together to create the soundscape of a person existing in that past. The soundscape is a combination of the acoustic properties of sound, space, and the individual. However, the acoustic nature of historical sounds *will* affect us as human beings and *will* evoke some kind of emotional response—even if it could be argued that this response is not "historically authentic."[23]

The next question to ask, then, is if sounds, music, and voices from the past can affect us in certain ways, can we deliver those sounds using AR to enable an in situ experience?

Aural Augmented Reality (AAR)

Audio tours using a handheld device rented or borrowed from a museum that guides a visitor through an exhibition has been a staple of many museums and heritage sites since the 1950s.[24] Once a bulky device that had

to be curated and maintained by the museum or heritage site, audio tours are quickly taking advantage of the smartphone-enabled age and releasing their tours as downloadable apps or podcasts. This is democratizing the audio tour, allowing new and alternative tours of museums and cities to be released and followed, and potentially undermining the "truth" of the official tour. While we recognize that the humble audio tour is a form of aural AR, experienced in situ and influencing the way the user experiences a space, we argue that such tours merely serve as a narrative-led experience of a space (much as a tour guide in book form would) and do not often explore the haptic or more immersive properties AAR promises.

Some applications have taken the idea of the audio guide further, such as the SoundWalk project, which offers alternative tours of the Louvre with a *Da Vinci Code* theme, or walking tours of the Hassidic areas of Williamsburg narrated by famous actors and members of the community.[25] What makes the SoundWalk tours different is that they are GPS-powered and place-specific; for instance, you are told to open specific doors when they are in front of you, or to look left or right to see individual features. With high-quality narration, sound-recording, and music and sound effects, these tours also play with the notion of self, melding the listener with the narrator: ". . . Okay, for today you [the listener] are Joseph, that's my Hebrew name; that's my Jewish name, and that's your name, for today we are one."[26] Through its "high-resolution" aural experience, the SoundWalk tours' acting, sound effects, music, and beguiling narrative all come together to give listeners a feeling of immersion; listeners are encouraged to get lost in the experience, following the voice in their head.

An application that also uses the immersive aspect of storytelling to good effect is the fitness app "Zombies, Run!,"[27] which is designed to aid a fitness regime by making running training more interesting. Logging into the app, users take on the role of "Runner 5," a soon-to-be-hero who is going to save the world from the zombie apocalypse. The app utilizes the user's GPS location and compass to direct them on a run around their local neighborhood, but they are continually being pursued by virtual zombies. Go too slowly and the sounds of the zombies will catch up to the users, who hear their ragged breath as they chase them around the park. As part of the run, users can also collect virtual medical supplies or water bottles—available through the use of in-game voice—all of which help stave off the apocalypse. While collecting supplies gamifies what might be seen as mundane exercise, the app's visceral sounds of a pursuer getting closer to the runner add an emotional level to the physical exertion of being out of

breath, tired, and aching, and creates an immersive experience. The runner is not just trying to better her time—the runner is escaping zombies and trying to save the world. The drama throughout is created and magnified mainly through sound.[28]

The SoundWalk project tours and the "Zombies, Run!" app were not specifically created with an ear to exploring and experimenting with historical sounds or soundscapes. Yet the immersive narrative (audio tours) and the gamification of a journey through an alternate present (Zombies, Run!) do offer lessons.

Three Archeological/Historical Aural AR Case Studies

Historians and archeologists are currently experimenting with AAR technology not just as a means to tell a story, but to allow users to "feel" the sounds and be affected by what they are hearing. Three AAR apps presently in development can help us see ways we might move beyond the visual interface, concentrating instead on the power of sound to direct, affect, and allow alternate interpretations. Although the following case studies are examples of prototype applications and proofs-of-concept rather than fully fledged applications with many users, they nevertheless show how sound can enhance in situ historical experiences.

Bronze Age Roundhouses

As part of his research using the embodied GIS to explore a Bronze Age settlement on Bodmin Moor, Cornwall, United Kingdom, Stuart Eve used a form of aural AR to aid navigation and immersion in the landscape.[29] By using the Unity3D gaming engine (which can spatialize sound), Eve created a number of 3D audio sources that corresponded to the locations of the settlement's houses. In the modern landscape the ancient houses are barely visible on the ground as circles of stones and rocks, making it hard to discern where each house is. Yet because the resulting app was geolocated, users could walk around the settlement in situ and hear the augmented sounds of the houses (indistinct voices, laughing, babies crying, etc.), which got louder or quieter with distance from each sound source.

Eve then introduced virtual models of the houses to act as audio occlusion layers, simulating the effect of the house walls and roofs in dampening the sounds coming from within—and only allowing unoccluded sound to emit from the doorways:

> At first, the occlusion of the sounds by the mass of the houses was a little disconcerting, as [visually] the buildings themselves do not exist. However, the sounds came to act as auditory markers as to where the doorways of the houses are. This then became a new and unexpected way of exploring the site. Rather than just looking at the remains of the houses and attempting to discern the doorway locations from looking at the in situ stones, I was able to walk around the houses and hear when the sounds got louder—which indicated the location of the doorway.[30]

By modelling sound sources and relating them to the archaeological evidence, Eve encourages questions about the site's use that visitors can explore in situ. For instance, if some of the houses were used for rituals (as is indicated by the archaeological evidence), what sort of sounds might these rituals make, and how would these sounds permeate the settlement? More prosaically, if animals were kept in a certain area within the settlement, how would their sound affect the inhabitants? How far could people communicate across the settlement area using calls or shouts?

Historical Friction

Inspired by the work of Ed Summers (of the Maryland Institute for Technology in the Humanities), Historical Friction is a sound-immersion app in the style of Zombies, Run! Summers programmed a web app called Ici, French for "here," which uses the native browser's abilities to "know" where it is in space and to search for and return all of the Wikipedia articles that were geotagged within a radius of that location.[31] In its original form, it returned a list with a brief synopsis of each article, but in its current iteration, Ici returns articles as points on a map, along with the article's status (e.g., stub, "needs citations," "needs image," and so on). Summers's intent was for the app to work as a call to action, encouraging users to expand the coverage of the area in Wikipedia.

Visually, it can be impressive to see dots on the map as an indication of the "thickness" of the digital annotations of our physical world—a thickness that suggests how difficult it can be to physically move through places dense with historical information. But we wanted to exploit this idea through the haptic nature of sound. Historical Friction makes that possible.[32]

Historical Friction deliberately plays with the idea of creating a break in presence as a way to focus attention on areas that are thick and thin

with digital annotations about the history of a place. To do so, Historical Friction initially took the output from Ici and fed it through a musical generator called Musical Algorithms, generating "music" that would be an acoustic soundscape of quiet or loud, pleasant or harsh tones as one moved through space, creating a kind of cost surface, a slope. As we iterated, we switched to a text-to-speech algorithm so that, as Ici loads the pages, the text-to-speech algorithm whispers the abstracts of the Wikipedia articles, all at once, in slightly different speeds and tones. Our goal was to make it painful, to increase the noise and discords, so that users would be forced to stop still in their tracks, take off their headphones, and look at the area with new eyes: Would the sound push the user from noisy areas to quiet areas? Would users discover places they had not known about? Would the quiet places begin to fill up as people discovered them?

Voices Recognition

During the inaugural York University Heritage Jam, an annual cultural heritage "hack-fest," a group of archeologists, artists, and coders took the Historical Friction application as inspiration and created an AAR app called Voices Recognition. According to its creators, "Voices Recognition is an app designed to augment one's interaction with York Cemetery, its spaces and visible features, by giving a voice to the invisible features that represent the primary reason for the cemetery's existence: accommodation of the bodies buried underground."[33]

To achieve this goal, the app geolocates each of the graves in the cemetery and attaches it to a database of online census data, burial records, and available biographies of the persons buried within the cemetery. Using GPS and compass to geolocate the user within the cemetery, the app then plays the contents of this database for every grave within 10 meters of the user. In the example application, the data is voiced by actors; however, the full application will probably use computer-generated voices, due to the number of graves in the cemetery and the sheer amount of corresponding data.[34] Here, the effect of linking sound and place would inevitably make the abstract data—the deceased—tactile and visceral for users. Moving among grandiose individual monuments, users would hear the whispers of single stories; in other places, they would experience a deafening cacophony of voices—especially in areas of mass, unmarked graves where voices literally shout out and clamor to be heard. Collectively, these sounds would completely invert the conventional cemetery experience.[35] If this app were to be made live, the designers would need to think carefully about

which material would be suitable for the intended sphere and about how to best present and distribute that material for greatest effect, yet the concept highlights the ways audio can relate to a cultural location at a much closer, personal level than visual overlay and presentation alone can produce.

Building an Aural, Haptic, AR to Hear the Past

In a guest lecture to a digital history class at Carleton University in the fall 2014 semester, Colleen Morgan recounted her experience with the Voices Recognition app when it was being tested: "Voices, in the cemetery, was certainly the most powerful AR I've experienced."

Building a convincing visual AR experience that does not cause any breaks in presence is the holy grail of AR studies. It is also something that is virtually impossible to achieve when we consider everything that can generate a break in presence: the mediation of the experience through a device (head-mounted display, tablet computer, smartphone, etc.), the quality of the rendering of the virtual objects, the level of latency in software that delivers the experience to the eyes. The list is both endless and scaleless; once you "solve" one break in presence, another occurs. The goal then can never be to completely eliminate breaks in presence, but instead, to recognize them and treat them with an historian's caution.

Indeed, we can play with them deliberately and use their inevitability to underline the broader historical points we wish to make. For example, the use of artificial crescendo and diminuendo (such as with the Historical Friction and the Voices Recognition applications) arrests users, making them stop and consider why the sounds are getting louder or quieter. Similarly, by inserting prehistoric sounds into the modern landscape, Eve creates an anachronistic environment—sounds that should never be heard in the present, generating a clear break in presence—but one that jars our cognitive intentional state and prompts us to examine what that sound might be and why it might have been placed in that particular location.

In this way, these case studies show that AAR does not always have to be a "recreation" or a fully immersive experience. Instead, much as we would treat the written word as the result of a process of bias (what is represented) and production (the quality of experience), we should treat any AR experience as the result of these processes and one more: delivery (the way in which it is delivered). Yet hearing the past requires that we pay attention to more than the effects. We must consider the *affect* if we are to prompt the kind of historical thinking we should wish to see in the world.

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Robert MacDougall is an associate professor in the Department of History at the University of Western Ontario and an associate director of Western's Centre for American Studies. He studies the history of information, communication, and technology. He is the author of *The People's Network: The Political Economy of the Telephone in the Gilded Age* (University of Pennsylvania Press, 2013) and co-creator of *Tecumseh Lies Here*, an augmented-reality game for history education that explored the War of 1812. He is a longtime player and sometime designer of tabletop board and role-playing games, and is interested in all varieties of playful historical thinking.

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