Information Design Journal 22(3), **237–246**

DOI: 10.175/idj.22.3.04sea

Patricia Search

Information design opportunities with augmented reality applications

Keywords: augmented reality, interaction design, multisensory design, relational aesthetics

Interaction design and augmented reality applications map information relationships between physical and virtual worlds. Mobile devices provide new opportunities for integrating digital graphics, text, and sound with the surrounding physical environment. Designers and artists are experimenting with innovative applications that present challenges in information design research and praxis. This paper explores the following dimensions of augmented reality that are integral to applications in information design that use this technology: semiotics of space and time; multisensory design; relational aesthetics, and kinesthetic interaction that incorporates gestures, physical movement, and embodiment into the interactive process.

1. Introduction

Various forms of augmented reality (AR) have been used in the entertainment and television business for some time. Movie special effects use digital compositing to layer virtual and real images. Television weather reports use chroma keying to display virtual data on a screen behind the weather reporter. Sports broadcasts for golf and tennis tournaments use digital graphics to show the trajectory of the balls. Swimming events often show a digital line moving ahead of the swimmers to indicate where the swimmers need to be in order to break existing records. Broadcasters can target specific audiences and selectively insert advertisements into the broadcast image (e.g., the outfield wall of a baseball stadium) using electronic billboards. Various forms of augmented reality have been incorporated into military training, flight simulators (military and commercial), and training for surgical and medical procedures.

Today, mobile devices create new opportunities to use AR in interaction design for business, marketing, education, and entertainment. AR applications can be very useful for travelers who want information about hotels, restaurants, museums, etc. when they reach specific destinations. Applications, such as the one by Hidden Creative shown in Figure 1, can help contractors, architects, and designers save time and money by enabling them to see how architectural changes and furnishings look in a specific physical location. They can easily modify their choices and show various options to customers.

Many AR applications layer too much data on the screen which interferes with the ability to see other information in the space. The interface design shown in Figure 1 uses transparent backgrounds, minimum

Figure 1. An example of an augmented reality browser that provides designers with an intuitive interface for viewing different types of office furniture in a specific space. Copyright Hidden Creative Ltd. 2010.

text and graphics, and a screen layout for the data which do not obscure the view of the virtual furniture or the physical office space. The browser also applies design research which indicated that AR interfaces should incorporate familiar touchscreen gestures and provide visual feedback (e.g., in this application, scale and perspective for the furniture) to represent spatial relationships, instead of using textual information (e.g., numbers) to communicate these relationships (Carlos Santos et al. 2016).

AR applications often use narrators to speak directly to the audience and engage them with the information. The Science Museum in London has developed an augmented reality app called "Science Stories" for its Making of the Modern World gallery. When visitors point their mobile phones at digital markers in the gallery, a virtual television personality, James May, appears and begins talking about the objects in the exhibit (Figure 2). The app can be used at the museum or downloaded for use at home.

These types of AR applications are changing the way we use audiovisual elements in information design. However, AR design has the potential to define

Figure 2. In the London Science Museum, viewers can use an app to learn more about exhibits from television personality James May. The image is courtesy of the Science Museum/Science & Society Picture Library.

other forms of dynamic information design that go beyond overlaying static virtual information onto the physical space or objects. We can draw inspiration from artists and designers for some of these new directions in information design. For example, science and art come together in a work by artist Tamiko Thiel titled *Fractured Visions: To See Again* (http://www.tamikothiel.com/AR/fracturedVisions.html). The work includes two installations, *Multiplicities* and *Diffusions*, which were commissioned by the AXNS Collective in collaboration with Dr. Dominic ffytche[1] from King's College London. The installations illustrate medical conditions that affect vision. *Multiplicities* is inspired by the "polyopia" syndrome which causes replicas of an object in the field of vision to appear (Figure 3). *Diffusions* is inspired by the "illusory visual spread" syndrome where objects within the field of vision may take on the colours and textures of neighbouring objects (Figure 4). Instead of static scientific illustrations, we can simulate what humans with these particular eye disorders experience using physical stimuli. These types of AR applications create empathy in information design that can enhance communication and the understanding of a problem (Billinghurst 2014; Lukosch Billinghurst, Alem & Kiyokawa 2015).

Clara Boj and Diego Diaz integrated physical and virtual spaces in the installation titled *Be Careful, Fragile*, which was created for an international contemporary art exhibition. In this work, viewers see a virtual vase appear on top of a real pedestal similar to the ones holding actual works of art in the exhibition (Figure 5). By moving their hands over the pedestal, viewers can interact with the work and knock over the vase which falls to the ground and breaks. We can draw inspiration from this work and design AR applications that engage the viewer and augment the audiovisual forms

Figure 3. *Fractured Visions: Multiplicities* by Tamiko Thiel is inspired by the "polyopia" syndrome which causes replicas of an object in the field of vision to appear. Copyright 2014 Tamiko Thiel.

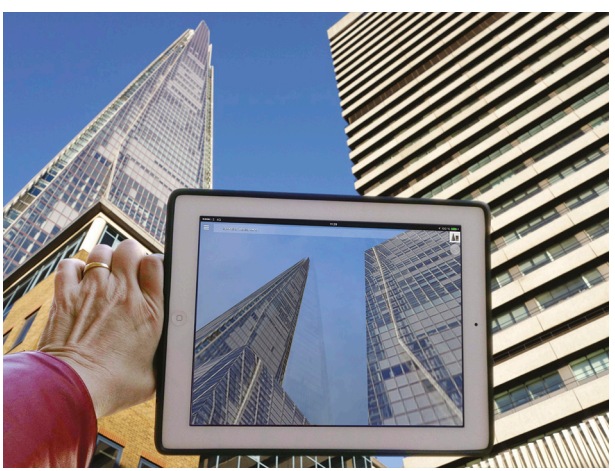

Figure 4. *Fractured Visions: Diffusions* by Tamiko Thiel is inspired by the "illusory visual spread" syndrome where objects within the field of vision may take on the colors and textures of neighboring objects. Copyright 2014 Tamiko Thiel.

Figure 5. Clara Boj and Diego Diaz (www.lalalab.org) used augmented reality to create an engaging experience that transcends virtual and physical spaces. Clara Boj & Diego Diaz, Attribution 4.0 International (CC BY-NC 4.0).

of information design that are traditionally found in museums and art galleries. For example, a museum application could allow viewers to point a mobile device at a work of art, and then, using the AR virtual interface, outline elements of the work or change colours, textures, and proportions to gain a better understanding of the visual relationships in the work. These applications would provide a dynamic, interactive form of analysis that complements the written or oral descriptions about the art or objects in the museum or gallery. These types of virtual explorations remain "rooted" in the real world because the original work is always present, and the viewer can continually refer to the physical attributes of the object, such as scale or the tactile qualities of materials in the work. Social discourse with other viewers can also be incorporated into the app to add new perspectives and interpretations.

2. Future directions

The field of augmented reality is still evolving. So many creative AR applications will emerge in the near future that we cannot even anticipate at this time. However, a few specific areas of AR design are worth noting because they have the potential to define new forms of information design, as well as redefine the way we collaborate and develop creative concepts for projects.

AR applications can incorporate different sensory modalities to augment the way information is presented. This multisensory approach to information design can be very helpful for communicating information to impaired individuals. For example, in multisensory design, aural and tactile cues, haptic interface designs, and ambient interfaces (that use sensory stimuli in the surrounding architectural space to communicate specific information) could help individuals who are visually impaired (Wisneski et al. 2008).

Future directions in AR will also include a focus on collaboration and spatial augmented reality (SAR). Collaboration in AR enables participants to interact with physical objects from remote locations and to access information about the objects or space, as well as add new annotations. Recent applications include systems for equipment maintenances (Gauglitz et al. 2014; Odat et al. 2013) and systems for police investigation and firefighting (Datcu et al. 2014 a b).

In spatial augmented reality, a room serves as a blank box in which participants use gestures and physical movement (embodiment) to interact with virtual images and text that are projected onto walls or objects in the physical space (Thomas et al. 2011). Research has shown that this type of AR experience can improve the work and creativity of participants, and as a result, these spaces can be resources for artists and designers, as well as work spaces for other groups that need to do creative collaborative work (Felip et al. 2015).

3. Design dimensions in augmented reality

There are multiple dimensions of design in AR that contribute to information design theory and applications. To begin, there are layers of virtual data which are placed on top of images in the physical environment. The virtual data, which may consist of numerical, textual, audio, or visual information, requires cognitive processing of facts and analytical relationships. The information from the real world creates additional layers of audiovisual data and aesthetic details which add cultural, historical, and social context. Many designs, especially AR applications that focus on the use of different sensory modalities, collaborative computing, and spatial augmented reality, require new forms of information design that integrate the physical movements of the viewer into the interface design. These diverse layers of cognitive and sensory information in AR applications incorporate the semiotics of space and time, multisensory design, relational aesthetics, and kinesthetic interaction into information design.

3.1 Semiotics of space and time

Gaines (2010) described the semiotics of space as "a descriptive process enquiring into the relevant significance of sign relations between objects and their spatial contexts" (p. 78). Augmented reality applications take this definition to another level as they create new types of spaces. Virtual and physical spaces overlap and combine different information and spatial relationships defined by images, sound, and text. Images integrate space and time into a spatial format that permits diverse viewer interpretations. Text defines linear, sequential spatial relationships, while audio can be both spatial and linear (sounds penetrate space, but melodic sequences are linear). The granularity of audiovisual spatial representation ranges from specific or localized representation, which is achieved with graphics, to infinite or non-localized space, which is achieved with sound (Search 2003). Visuals and sound define layers of spatial depth that enhance the immersive experience for the viewer (Search 2008).

Augmented reality also creates a new type of space that exists between the virtual and real worlds. Mobile devices can blend virtual and physical spaces and add new dimensions to the spatial experience. GPS systems track and identify locations, and social networking and other forms of online communication allow users to engage in private and public conversations as they move through the space. Annet Dekker (2008) described this space as a "new hybrid space that is constantly moving between the virtual and the actual" (Introduction, para. 2). Adriana de Souza e Silva (2006) noted that this space is also as a "nomadic" space because not only the paths change, but so do the points of location defined by the mobile devices which move with the viewer (p. 267). The nomadic nature of mobile computing also highlights the temporal dynamics of these interactive environments. Time is further emphasized by the fact that viewers continually update and post their augmented reality experiences on social networks.

Christine Ross (2009) pointed out that augmented reality's "potential innovativeness lies in its ability to generate new ways of perceiving for the spectator or to disclose what was previously unperceived—unseen, unheard, unfelt, unsmelt" (Introduction section, para. 4). The multiple layers of spatial and temporal information can augment the viewer's understanding of a location, event, or object.

Humans have used space to organize ideas since the ancient Greek and Roman rhetoricians developed the method of loci or memory palace, a mnemonic device that helped them remember their speeches by visualizing objects in specific locations (Yates 1966). Gestalt psychologists pointed out that humans have the innate ability to use space to group and organize information,

and researchers also learned that we automatically use the orientation of our bodies in space to help us identify objects (Rock 1974).

These intuitive abilities to interpret space make spatial organization an important design element in AR applications and interface designs. Frank Biocca, Arthur Tang, and David Lamas (2001) pointed out:

> Spatial organization in interfaces or any representational system can be powerful because so much of the brain is dedicated to compute the location of objects and beings in a relative, not absolute, coordinate system principally organized around the body of the user (Theoretical and Design Issues section, para. 2).

Peter Anders (1999) referred to virtual space as "anthropic cyberspace" and described this type of spatial communication as a universal language:

> Spatial, anthropic cyberspace links to a pre-linguistic knowledge of the world—a knowledge crucial to our navigation, operation, and communication. We understand spatial representation regardless of its cultural origin. Spatial thought—a shared human trait—underlies the images of objects and spaces from all cultures (p. 10).

Unfortunately, with many current AR applications, viewers tend to limit their perception of information by focusing primarily on the technology and virtual data. The surrounding environment becomes a backdrop for the information, rather than an integral part of the communication experience.

AR designs need to take into consideration the fact that locations in space are more than a set of coordinates, dates, ratings, and other compiled facts. Emma Ota (2008) described location as follows:

> Location is not a set of coordinates, it is not something static and easily measurable; it is not a case of physical geography but it is a state which exists through the complex interplay of history, culture, socio-politics, economics and technologies. Location is a multifaceted context, a situation and a state of being and is not necessarily linked to the ground beneath our feet (p. 361).

The AR interface designs on mobile devices also hinder the perception and understanding of the surrounding physical space. The virtual and physical information appears in the window or frame of a smart phone or tablet. These frames form boundaries that define the space and how we interpret the information in that space. Only select elements from the physical space are visible within the frame, creating a focus on that information, rather than the information outside the frame. The frame itself suggests a finite limit because the experience is defined by discrete groups of data and spatial relationships. There is a lack of continuity in the way viewers see the physical environment which hinders their ability to define a sense of place. The technology emphasizes specific units of information at defined moments in time, rather than highlighting the connections between memories, places, and experiences.

The interface design in augmented reality applications should encourage the viewer to see and experience the multiple dimensions of the virtual and physical space in the application. When viewers focus too much on the digital data, they fail to observe how people interact in the physical space. They do not look for the details in the actual environment that define how the space is used by different groups to create a sense of identity and community. Elliot Gaines (2010) defined "identity" as "the essence of embodied consciousness, providing the location of experience and the origins of the self in relation to others" (p. 76). He noted that this awareness of self within a space evolves with an understanding of the

events that occur in the space. As Tapio Mäkelä (2008) noted, "places become meaningful through individual and shared acts of signification, not because they register as location data" (para. 2).

3.2 Multisensory design and relational aesthetics

Augmented reality applications can use different sensory modalities in the information design. However, with most augmented reality applications, there is an emphasis on visual information. Dekker (2008) pointed out that sound can open up subjective connections in listeners and offset the reliance on objective factual data. Diverse media can engage viewers by creating sensory environments that help them relate to new information (Search 2009). Audio and visual media create affective domains that enable viewers to connect with new ideas and experiences on an emotional level. Once they are engaged and feel comfortable on this level, they are more likely to be receptive to the cognitive information that follows (Gazda & Flemister 1999). For example, Toozla is a mobile service that provides multisensory experiences by using global positioning to trigger audio tours, stories, and local information when the viewer points a mobile device camera at an object. Using this type of service, audio augmented reality can replace the standard pre-programmed, linear audio tours that have been used in guided city tours, museums, and other types of public exhibitions. Random access to the information gives visitors the freedom to move around an exhibit or other physical location and view artifacts in any order.

Relational aesthetics is also an element in AR design. Nicolas Bourriaud (1998) coined the term "relational aesthetics" as a way to locate art and design theory and application within the context of human relations and culture. Relational aesthetics defines the social structures or relationships in contemporary art and design that link curators, artists, and audiences. Relational aesthetics, when situated within social media and online interaction, expands the meaning of visual information by breaking down the boundaries between diverse groups and incorporating different perspectives in the design discourse. With interactive AR technology, the definition of relational aesthetics can also refer to the aesthetic connections that evolve when spatial, temporal, and sensory networks continually change and create new patterns and relationships. Information designers need to consider how these dynamic aesthetic and semiotic relationships impact the interpretation and communication of information in an AR application.

3.3 Kinesthetic interaction design

AR applications will provide new opportunities to explore the potential for using kinesthetic interaction in information design. With mobile devices and interactive games, gestures and physical movement are integral to the interface design. There will be an increased focus on physical interaction in AR interface design as new applications emerge. The physical interaction of the viewer in a virtual space creates a heightened awareness of space that can lead to new perspectives. With these new technologies, the gestures and movements of the participants become part of the design and define a spatial grammar of interaction that integrates the audiovisual computer interface with the physical space of the viewer (Search 2006).

Kinesthetic interaction design can help the viewer understand the visual and cognitive relationships defined in the virtual space (Search 2006). Tom Djajadiningrat, Ben Matthews and Marcelle Stienstra (2007) said this "semantics of motion" shifts action from a purely functional role to an aesthetic role that is "necessary" for envisioning an experience (pp. 10–11). In addition to the specific movements, the space between actions can contribute meaning to an interactive experience and add another dimension

to the relational aesthetics. Djajadiningrat, Matthews, and Stienstra (2007) identified this "choreography of motion" as "the expression or beauty of the movement," and used the term "arch of tension" from the performing arts to describe how the "expression of the work unfolds" (p. 31). This sense of embodiment, created by the use of gestures and physical movements, clarifies and personifies the interactive experience by physically engaging the viewer and reducing the objective and impersonal nature of the virtual data (Klemmer, Hartmann & Takayama 2006). Physical movement augments our understanding of information by leveraging "body-centric experiential cognition" (Klemmer, Hartmann & Takayama 2006: 144). Rokeby (2008), an artist who has created augmented reality artwork, acknowledged the significance of physical interaction and embodiment: "Because the computer is purely logical, the language of interaction should strive to be intuitive. Because the computer removes you from your body, the body should be strongly engaged … And because the computer is objective and disinterested, the experience should be intimate" (para. 9).

Gestures and bodily movements also constitute a universal visual language because they are based on shared and tangible experiences. Curtis LeBaron and Jürgen Streeck (2000) pointed out that gestures provide a bridge between tactile experiences and the abstract conceptualization of these experiences. LeBaron and Streeck highlighted the work of the French philosopher Étienne Bonnot de Condillac who felt that gestures "constituted the original, natural language of humankind" because they formed symbols and a social language based on common experiences (LeBaron & Streeck 2000: 118). Condillac (1746) called these symbols or signs *sensations transformées* or transformed sensations (p. 61) because they referred to "the entire complex of affect, desire, sensory perception, and motor action that makes up what nowdays we might call 'embodied experience'" (LeBaron & Streeck 2000: 118).

4. Final comments

James Vallino (1998) pointed out that the ultimate goal of augmented reality is to "create a system such that the user cannot tell the difference between the real world and the virtual augmentation of it" (Augmented Reality section, para. 1). We still have to overcome many design challenges before we can create intuitive user experiences that achieve this objective.

Future directions in augmented reality will impact information design by placing an emphasis on the use of different sensory modalities to represent information and define intuitive interfaces that use touch, ambient sensory cues, and kinesthetic interaction design to define the information. Designers will need to be familiar with multisensory design and how to use the senses in interface design. Designers will also need to be aware of the latest research in cross-modal perception in order to design effective multisensory information spaces.

Information designers should also have an understanding of the viewer's psychological dependence on digital media and mobile devices. Alexis Madrigal (2012) noted that top executives are concerned that the lure of technology creates a dependence that can affect productivity and interpersonal communication. Moreover, if we rely on the digital information to "augment" our understanding of our surroundings, we may fail to see information and relationships that are visually obscured by the layers of media, and we may ignore information communicated through other senses such as sound, touch, and smell. An insightful concept film by Keiichi Matsuda titled *Hyper-Reality* (http://hyper-reality.co) explores what the future may look like as physical and virtual worlds intersect (Figure 6).

In AR applications, interface designs define different types of space that are created with blended environments. Rhodes (2014) concluded that we are

Figure 6. Scene from Hyper-Reality where the physical world is saturated in media. Copyright Keiichi Matsuda Ltd. 2016. All Rights Reserved.

in a period of post-mediation in which we are now struggling to redefine our relationship to the interface and the machine. In augmented reality applications, the semiotics of space and time, multisensory design, relational aesthetics, and kinesthetic interaction are design elements which have the potential to expand our perspectives and our understanding of the world around us. These elements contribute to a new audiovisual language in contemporary information design discourse and praxis. Understanding the complex semiotics and dynamic aesthetics of this language will help us define innovative ways to expand the use of augmented reality applications in information design.

Submission date: 27 July, 2016
Accepted date: 20 September, 2016

Note

1. The correct spelling of 'ffytche' has two lower case 'f's—an archaic spelling that has survived until the current day.

References

British Broadcasting Corporation. (2012). *Top Gear presenter James May meets his virtual self*. Retrieved from http://news.bbc.co.uk/2/hi/programmes/click_online/9718563.stm

Billinghurst, M. (2014). Using augmented reality to create empathic experiences. In *Proceedings of the 19th International Conference on Intelligent User Interfaces* (pp. 24–27).

Haifa, Israel. Biocca. F., Tang, A., & Lamas, D. (2001). Evolution of the mobile infosphere: Iterative design of a high information-bandwidth, mobile augmented reality interface. In *Proceedings of the International Conference on Augmented, Virtual Environments and Three-dimensional Imaging, ICAV3D'*2001, (pp. 6–9).

Mykonos, Greece. Bourriaud, N. (2002). *Esthétique relationnelle*. Dijon: Les Presses

du Reel. Condillac, E. (1746). *An essay on the origin of human knowledge, being a supplement to Mr. Locke's essay on the human understanding*. London: J. Noursse.

De Souza e Silva, A. (2006). From cyber to hybrid: Mobile technologies as interfaces of hybrid spaces. *Space & Culture*, 9(3), 261–278. DOI: 10.1177/1206331206289022

Djajadiningrat, J., Matthews, B., & Stienstra, M. (2007). Easy doesn't do it: Skill and expression in tangible aesthetics. *Personal and Ubiquitous Computing*, 11(8), 657–676. DOI: 10.1007/s00779-006-0137-9

Felip, F., Chulvi, V., Garcia, C., Diaz, D., Galan, J., & Mulet, E. (2015). Technologies for building a spatial augmented reality prototype to act as a creative resource for designers and artists. *International Journal of Visual Design*, 8(2), 1–10. DOI: 10.18848/2325-1581/CGP/v09i03/38741

Gaines, E. (2010). *Media literacy and semiotics*. New York: Palgrave Macmillan. DOI: 10.1057/9780230115514

Gazda, R., & Flemister, M. (1999). Design and production of video for instructional multimedia: Psychological implications and proposed guidelines. *Journal of Visual Literacy*, 19(1), 85–98. DOI: 10.1080/23796529.1999.11674546

Klemmer, S.R., Hartmann, B., & Takayama, L. (2006). How bodies matter: Five themes for interaction design. In *Proceedings of Designing Interactive Systems, DIS* 2006 (pp. 140–148). New York: Association for Computing Machinery (ACM).

LeBaron, C., & Streeck, J. (2000). Gestures, knowledge, and the world. In D. McNeill (Ed.), *Language and Gesture* (pp. 118–138).

Cambridge, UK: Cambridge University Press. DOI: 10.1017/CBO9780511620850.008

Lukosch, S., Billinghurst, M., Alem, L., & Kiyokawa, K. (2015). Collaboration in augmented reality. *Computer Supported Cooperative Work*, 24(6), 515–525. DOI: 10.1007/s10606-015-9239-0

Madrigal, A. (2012). Are we addicted to gadgets or indentured to work? In *The Atlantic Monthly*. Retrieved from http://www.theatlantic.com/technology/archive/2012/07/are-we-addicted-to-gadgets-or-indentured-to-work/260265

Makela, T. (2008). Technologies of location: Affect of place in artistic uses of mobile and social networks. In *Proceedings of ISEA 2008, 14th International Symposium on Electronic Art*. Singapore: Inter-Society for the Electronic Arts (ISEA). Retrieved from http://www.isea-webarchive.org/portal

Ota, E. (2008). Inaccurate coordinates. In *Proceedings of ISEA 2008, 14th International Symposium on Electronic Art*. Singapore: Inter-Society for the Electronic Arts (ISEA). Retrieved from http://www.isea-webarchive.org/portal

Rhodes, G. (2014). Augmented reality in art: Aesthetics and material for expression. In V. Geroinko (Ed.), *Augmented reality art: From an emerging technology to a novel creative medium* (pp. 127–137). London, UK: Springer.

Rock, I. (1974). The perception of disoriented figures. In R. Held (Ed.), *Image, object, and illusion* (pp. 71–78). San Francisco: W. H. Freeman and Company.

Rokeby, D. (2008). Lecture for Info Art, Kwangju Biennale. Retrieved from http://www.davidrokeby.com/install.html

Ross, C. (2009). Augmented reality art: A matter of (non)destination. In *Proceedings of the Digital Arts and Culture Conference*. Irvine, CA: University of California. Retrieved from http://escholarship.org/uc/item/6q71jozh

Santos, C., Miranda, B., Araujo, T., Carneiro, N., Marques, A., Mota, M., Meiguins, B. (2016). Guidelines for graphical user interface design in mobile augmented reality applications. In S. Lackey & R. Shumaker (Eds.), *Virtual, augmented and mixed reality: Proceedings of the HCI International 2016 Conference* (pp. 71–80). Zurich: Springer.

Search, P. (2003). The metastructural dynamics of interactive electronic design. In R. Griffin, V. Williams, & J. Lee (Eds.), *Turning trees* (pp. 1–9). Lorreto, PA: International Visual Literacy Association.

Search, P. (2006). The spatial grammar of interaction design: Weaving a tapestry of space and time in multimedia computing. In R. Griffin, B. Cowden, & M. Avgerinou (Eds.), *Animating the mind's eye* (pp. 185–190). Loretto, PA: International Visual Literacy Association.

Search, P. (2008). Kaleidoscope: The dynamic discourse of visual literacy in experience design. In M. vgerinou, R. Griffin, J. Giesen, P. Search, & C. Spinillo (Eds.), *Visual literacy beyond frontiers: Information, culturend diversity* (pp. 185–192). Loretto, PA: International Visual Literacy Association.

Thomas, B., Von Itzstein, G., Vernik, R., Porter, S, Marner, M., Smith, R, & Close, B. (2011). Spatial augmented reality support for design of complex physical environments. In *Proceedings of the IEEE International Conference on Pervasive Computing and Communications Workshops* (pp. 588–593). Seattle: IEEE.

Vallino, J. (1998). *Introduction to augmented reality*. Retrieved from http://www.se.rit.edu/~jrv/research/ar/introduction.html

Wisneski, C., Ishii, H., Dahley A., Gorbet, M., Brave, S., Ullmer B., & Yarin, P (2008). Ambient displays: Turning architectural space into an interface between people and digital information. In *International Workshop on Cooperative Buildings (CoBuild '98)*, pp. 22–32. London: Springer.

Yates, F. (1966). *The art of memory*. Chicago: University of Chicago Press.

About the author

Patricia Search is a multimedia artist and professor at Rensselaer Polytechnic Institute (Troy, New York). She conducts research on multisensory data design and cross-cultural communication and was awarded a Fulbright Specialist Grant to work on interaction design projects with two Australian universities. She exhibits her art throughout the world and received a Fellowship in Computer Arts from the New York Foundation for the Arts and the Creative Achievement Award from the International Visual Literacy Association (IVLA). She served as President of IVLA, Co-Editor-in-Chief of the *Journal of Visual Literacy*, and as a Fulbright Ambassador for the Australian-American Fulbright Commission.

Email: patriciasearch@yahoo.com