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IS WORKING WITH WHAT WE HAVE ENOUGH?

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Abstract

Augmented reality (AR) digital environments have introduced a new complexity to digital investigation where augmented overlays of real objects may be momentary, changed, distorted and evade the usual methods for evidence collection. It is possible an investigator applying standard investigation methods factually reports a real situation and its digital context but has none of the relevant evidence. In this situation the potential for a fair hearing is low and the chance of retrial high. Such situations are unacceptably dangerous and require redress. In this paper the AR condition is considered in terms of its complexity and management during an investigation. The most important issue is awareness and the investigator factoring in the potential for augmentation in any investigation.

Keywords
Augmented Reality, Digital Investigation, Digital Evidence, Methodology, Blank spots

INTRODUCTION

People take for granted that the images they view in advertising shots are not exactly the same as the real product. This assumption extends across the full range of products people view from cars to movie trailers. However, each person has a tolerance level that triggers an alert when the image, sound or other sensory experience varies too greatly from the perceived reality. In part these are all learned experiences framed by mental maps that set expectations (Azuma, Baillot, Behringer, Feiner, Julier, and MacIntyre, 2001; Chen, Li, Dangelo, Gao and Fu, 2018). People expect that a two-dimensional image representing a three-dimensional reality will differ in many respects but are mentally ready for a fair representation and not deception. The cutting edge of augmented reality (AR) is in advertising AR and other lived experiences such as sports AR. Exposure to the sporting world on television has made many people accustomed to AR. Whether the sport is cricket, mountain climbing or horse racing, viewers expect to receive multiple overlays of information that make the competition easier to comprehend. AR enhances digital images, audio recordings, and mixed realities, in order to make reality bigger, better, and more accessible to a viewing audience. In such circumstances decisions are made, perceptions shaped, and actions taken. The human gains knowledge of real situations based on a transformation of the real into a construction and the comprehension of an illusion (Olszewski, Gnat, Trojanowska, Turek and Wieladek, 2017). AR is a blend of virtual reality (VR) and physical reality, which is different from pure VR that attempts to abstract the digital form from reality, for example in a game such as *Grand Theft Auto* (Qirat, and Mehreen, 2018). AR makes things that exist greater, as in size, extent, or quantity by using digital information to make human perception of actual, physical reality greater. It does not create a brand new, standalone plane of existence, as in a digital game but rather adds or subtracts from the information available to the senses in the physical world (Azuma, Baillot, Behringer, Feiner, Julier and MacIntyre, 2001). The outstanding problem is one of perception. How does a human perceive things to be? What reactions do they have? How is their decision making changed?

These questions are relevant to a digital investigator who must after an event investigate the residual digital artefacts for evidence in relation to the event. Today many real and virtual experiences merge in people's minds so that a simple physicalist documentation has insufficient scope for a comprehensive view of events. Evidence collection requires consideration of compliance and preservation factors so that the evidence may be acceptable to a court of law (Chen, Li, Dangelo, Gao and Fu, 2018). At the same time it must be sufficient in scope so as to avoid new evidence being submitted at later dates and retrials. AR introduces new challenges as it concerns human perception as well as technical factors. A digital investigator has to be aware of areas for the acquisition of potential evidence, the intricacies of the various technologies, and the matters that affect human perception, for example in the investigation of a motor accident. This paper is structured to review AR, to provide an AR example and then to discuss issues arising for investigator awareness. A sizeable portion of this paper is focused on awareness, and the constructs and perceptual phenomena of AR that impacts a comprehensive collection of digital evidence.

AUGMENTED REALITY

This section lays out the scope of the augmentation of the human five senses in order to appreciate the complexity of impacts on digital investigation. AR functions by both increasing and diminishing the digital information available to the human senses (Carmigniani, Furht, Anisetti, Ceravolo, Damiani, and Ivkovic, 2011). In some instances, information is added to assist human comprehension and in others, reduced to assist comprehension. An example of adding is TV sports coverage, and reducing is image cropping. In both instances, the risk of removing or adding information that impact human decision making in a real world has consequences for the vendors of the technology. When information is removed to lessen the amount of unwanted visual distractions in, for example, automated vehicular control, and then an accident may be associated with the action. The augmentation of reality may occur in any of the five human senses or a combination of each. The most common sense is vision, but hearing, touch, taste and smell also provide access for AR (Arth, Grasset, Gruber, Langlotz, Mulloni, and Wagner, 2015).

AR research has focused on how to augment the sense of sight. Much of the research has been into how to trick human eyes into getting the brain to comprehending images that are either enhanced or diminished in information. However, human eyes perceive accurately and are difficult to trick into accepting digital content as physically real (Liestøl, Rasmussen and Stenarson, 2011). The problem of digital displays in two-dimensions is solved by a variety of intermediary filters to create the illusion of three or more dimensions. The first attempts were TV screens and now holographic projections are augmenting the dimensional reality. Programmers mix or delete digital content with real images to let the human mind comprehend the image as real. These applications perform a variety of functions, from displaying digital content on two-dimensional images, to augmenting physical objects recognized in the real world. Walking directions are displayed directly atop the footpath a user sees through their device's video camera. Mobile devices are the biggest users but navigation is also a prominent motivator for augmenting visual perception in vehicles (Höllerer and Feiner, 2004). These navigational aids mix images of real world objects and relationships with digital information to make vehicle control easier for the pilot and driver. They also allow the pilot or driver to enter real world locations and situations that they have never experienced or seen before and perform safely. These include displaying driving directions over a driver's field of view, enhancing safety by highlighting roads in foggy weather or calling attention to road signs. In the advertising industry the addition (overlay) of information to images is a long established practice (Shengli, 2018). Projection mapping systems are able to track fast-moving objects so precisely that it can project an advertisement on a bouncing tennis ball or a low flying aircraft. Digital eyewear is a flagship research area in visual AR. The eyeglass has been a market leader and now mobile phones are being equipped so that users can hold a mobile device out in front of themselves to see the augmented overlay of their real environment (see Figure 1 as an example) (Qiu, Nguyen, Huy and Le, 2017).

Technologies that enhances the sense of touch are fewer in number as their reach is less, but after visual research this field has the most promise for growth and delivering meaningful AR experiences (Alkhamisi and Monowar, 2013). Products are available to turn touch computer screens into feel screens that generate any number of artificial textures, edges, or vibrations. It accomplishes this illusion through the use of touch pixels that have been named Tixels. Tixels work by sensing Coloumb's electrical force, and by passing an ultra-low electrical current into insulated electrodes. This creates a small attractive force to finger skin and by modulating the attractive force generates artificial sensations. The application can be generalized by wrapping a human hand or skin with a flexible sensor thinner than plastic wrap and ultra-light to create an e-skin. Another solution to haptic augmentation is precisely timed air puffs that create physical sensations. These surfaces of sensations can be managed to encapsulate a human experience and to augment reality (Van Krevelen, and Poelman, 2010). The Apple Watch provides an entry level haptic experience for users by providing physical feedback in a coordinated vibrator and skin touch. It can provide different kinds of haptic feedback and buzzing directionally to provide subtle directions or tapping lightly when a friend wants to say hello. FitBits also use haptic connectivity to monitor biometric behavior and to give user feedback.

The augmentation of human audio communication has a long history of use in the application of hearing aids that amplify sounds to compensate for human weaknesses. Sound conditioning where digital information is also removed is used in environments where there is information overload and also to control potential damaging sound waves (Wither, Tsai, and Azuma, 2011). Applied research projects have used and adapt sound waves into AR synthetic vision using auditory video representations for blind individuals to effectively see the real world around. Also next-generation hearing aids allow selective listening in noisy environments and filters for automatically blocking sudden or unexpected loud noises while allowing for emergency alert signals. Detailed information about individuals' physical health is better positioned at the ear than the wrist. Consequently, these devices will include multi-tasking and additional capabilities to effect, and augment hearing. Smell and taste are the least explored areas because they usually require chemicals rather than digital intermediation. However, they are important because they can directly affect emotion, mood, and memory. These triggers are useful in developing AR effects for humans whose other sensors are diminished or non-functional. Most smell and taste applications are analogue but researchers are developing proposals such as the ‘digital lollipop’ that can simulate taste. It works by fooling the human sense by varying the alternating current from the lollipop and slight but rapid changes in temperature (Brooks, 2009; Lyu, Song, and Cai, 2005). Advertisers could use this concept to include the taste of a product in an advertisement on a computer or television screen. Similarly, movies could become more interactive, allowing people to taste the food an actor is eating. The extension of the AR is to allow users with food allergies to taste the foods they cannot and gamers to get rewards. The market leader is the ‘Tongueduino’ that is a three by three electrode pad that rests on the tongue and connects to environmental sensors. Each sensor registers electromagnetic fields, visual data, sound, ambient movement or anything that can be converted into an electronic signal from the environment (Kiron, Kimberly, Tadayoshi and Franziska, 2018). In principle, it can allow blind or deaf users to ‘see’ or ‘hear’ with their tongues, or augment the body with extra-human senses.

AN EXAMPLE

AR is used in many different contexts to enhance human experience. For the purpose of this case study the augmentation is visual and the context retail sales. In figure 1 a shot of the supermarket isle is shown on a smartphone as the shopper goes about their purchases. It has many advantages for the shopper as they can load in their shopping list and the downloadable app will guide them to the appropriate locations for the required products. It will also give comparative price options and other useful information. For the retailer it also has many benefits such as promoting specials, soliciting customer loyalty, and so on. So the benefits are clear but how much of this is real? The products on the shelves are all packaged in AR jackets, logos and images, the handheld application is fully digital and manages the customer experience, and the entire retail environment is augmented towards convincing the customer to transact.

Figure 1. AR in the supermarket

In this situation consider the investigation of an alleged shop lifting event where a product is taken without the correct transaction processes being complied. It can be seen from the prosecution and defence perspectives. The prosecution can present evidence from digital surveillance cameras, the store guard and any other witness statements regarding a physicality or real event. The Customer, however, can argue that the store application said that the product taken was a complementary promotional gift this week, and present the digital evidence. This of course may be contested by the store. Was it a timing issue? A hoax that is placed by a hack? Or any other digital legitimation that contradicts law? But the contest here is between a physicality and a virtual abstraction.

An investigator would immediately image the smartphone and link the various stories around the event to a timeline. Such an investigation would show the legitimate taking of the product and the non-compliance with the legitimate transaction processes. However, the digital investigation of the smartphone may also show exactly what the customer claims in terms of the virtual defence evidence. The problem here is that many AR environments are very unstable and forensic records are not often kept. The VR environment on a customer smartphone varies from day to day and hour to hour. Some are even customised to the individual customer, their digital profile, their behaviour and location at the time. Often the ability of the investigator to reproduce the AR environment after an event is limited and in terms of having digital evidence that may be reproduced by another expert using the same methods is problematic.

THE DAUBERT CRITERIA

The Daubert versus Merrill Dow Pharmaceuticals Inc. case illustrates the bridge between science and law, but presents a scientific challenge for use of VR environments. It sets forth a five pronged standard for the admissibility of scientific evidence in a federal court. As the Daubert standard can be applied to any scientific procedure it is a particularly important step in the admissibility of evidence. The Daubert standard applies whenever scientific procedure is used to prepare and uncover evidence and comprises the following five guidelines (Table 1) to evaluate scientific testimony (Daubert v. Merrell Dow Pharmaceuticals, 1993).

Table 1: Guidelines from the Daubert decision

1	The scientific procedure must testable and be independently tested.
2	The scientific procedure should be published and subjected to peer review
3	Is there a known error rate or potential to know the error rate associated with the use of the scientific procedure?
4	Are there standards and protocols for the execution of the methodology of the scientific procedure?
5	Is the scientific procedure generally accepted by the relevant scientific communities?

The Daubert standard provides judges a set of guidelines for the objective acceptance of scientific evidence, yet there are no uniform sets of standards to gauge the competency of a digital forensics examiner or the effectiveness of digital forensic processes. The technical limitations of tools impacts scope and the ability to satisfy the Daubert guidelines and conformance. The requirement to satisfy guideline 1 is in jeopardy in AR environments. Volatility of information on a moment by moment basis will give different evidence at each moment and challenge testable procedures. Therefore, an evaluation framework is required to include the potential omissions that may appear in an AR investigation. In a business network environment, such as the example above, the following of traditional digital forensic methods may lead to erroneous results. Not only omissions will be present but substitutes will have taken the place of the event evidence. In such conditions far greater care has to be taken and a deeper understanding of the digital environment understood before data acquisition begins. The digital forensic report must document the steps undertaken by the examiner with sufficient detail to allow an independent third party to replicate the conclusions. In the AR context many elements become problematic and require new methods and procedures for investigation.

DISCUSSION

The work Digital Investigators get comes from civil and criminal assertion of the laws in relation to a wide range of human conduct. The discussion of AR complexity raises some of these issues that concern real property ownership and advertising. The data enhancement by AR technologies has potential for real property impacts and claims for damages (for example, NTB, 2018). The example of injuries sustained while playing the AR game Pokémon illustrates the general problem area, and cases where Digital Investigation has occurred. A more specific issue is the overlay of real properties by advertising or distorting layers of information that impact the value of the real property. This may occur once the real property has been digitized or information overlays that include words, colours and images may be projected onto a real property. In the digital world of TV this may include a competitor brand being overlaid on another or branding removed for clean shots. In the real world building and other objects or scenes may be projected onto in order to communicate an effect or message. Such distortion of reality can have recourse to law for an owner of real property who may claim trespass, nuisance, easement, protection, or other potentially liable claims. Real property is a term that distinguishes a physical parcel of land from other sorts of property, such as portable objects (personal property) or abstract, intangible expression (intellectual property). The ownership of real property carries the right to possess and exclude others, and consequently the complexity of digital rights and investigation in response to claims when AR impacts values.

The context is helpful in considering digital overlays of real property but many nonpossessory rights also exist that may be argued to allow a digital overlay without physically occupying it, for example, google maps. The law provides various remedies for violations of a landowner’s rights that may be considered in relation to AR. Trespass occurs when a person enters a property without permission and the owner may eject the trespasser and recover any damage that may have been caused. In AR this equates with disrupting a signal or transmission. Similarly a trespasser is afforded protection from harm unless they resist and minimal force may be used. In AR the way a trespasser is removed is equally important and no unreasonable harm to their person or properties may be actioned. Other property rights also require consideration such as nuisance and the right of quiet and peaceful enjoyment. Visual overlays can be in this category when the owner's perception is disturbed and the owner suffers emotional or financial harm. A more complex case arises when a person wearing an eyeglass or following maps on a mobile phone is shown advertising digitally plastered over every surface within view, including footpaths, trees, buildings, park benches, passing cars, lamp posts, the clothing of passers-by, and so on. The user in this instance has a right to switch off the unwanted augmentation of the physical reality. The problem is the preservation of this momentary evidence after a complaint is made, and the ability of the Digital Investigator to gain sufficient access to the VR environment at another time.

The manipulation of images is a marketing tool that is readily used. Digitally enhanced photos are central to media communications and use AR for the stylization. Some photos are manipulated to the point that the match between the real object and the augmented one is disconnected and legal arguments are raised to prevent the use. In some instances regulators have products removed from the market because the vendor's cannot not prove that the advertised products were able to produce results like the ones shown in the augment images. Fashion companies are also criticized on a regular basis for altering photos of clothing models to give them physical features so extreme as to be anatomically impossible. The difficulty of precise rendering and drive to win market result in augmented advertising that are unrealistic to the point of being deceptive. By definition, digitally enhancing physical reality is a fundamental element of what AR does. Also Television broadcasts (especially of sporting events) are increasingly using digital billboard replacement technology to overlay advertisements in the physical world with digital media from other companies. One company purchases the rights to depict the replaced physical banners in the broadcast, and the other to the physical sign and not to the broadcasts. AR allows the marketing practice and the use of such replacement technologies. AR is hence widely applied in advertising campaigns but promotes concerns of acceptability, deception, and ownership rights. For the Digital Investigator regulation is required that the advertising agencies are compelled to retain accurate logs of the dates, times, and content of VR alterations and promotions. This would be a step toward accountability and addressing some of the AR challenges for investigators.

CONCLUSION

In this paper we have raised the problem area of AR for Digital Investigators. The exploration of the AR condition throws up more and more challenges for standard digital forensic practices and the investigator must be constantly aware that an AR situation is involved in a case. The brief discussion points raised suggest that the legal implications of AR need to be a foremost consideration by those liberally offering the experiences. Either party resorting to physicalist explanations of events may find augmented abstractions overturning the world view, and the required explanatory power for scientific evidence rapidly diminishing. Digital Investigators require legislative help to assure the vendors of AR experiences are compelled to keep adequate records of their activities.

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