5. *'Taking the Plunge': The New Immersive Screens*[1]

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Abstract
Ariel Rogers addresses the contemporary experience of virtual reality technology and its long and volatile relationship to ideas of immersion. The multiplication and pervasion of screens has often been viewed as a break from previously dominant forms of screen engagement. Whereas viewers' encounters with the twentieth-century cinema screen (conceived as singular and static) has typically been framed as an experience of centred space marked by fixity and transfixion, the experience of enclosure in multiple-screen environments has often been conceptualized via concepts of spatial fragmentation and information flow. Contemporary VR sets confound this distinction: not only are they 'immersive' and centring, they are also unanchored, breaking the tight identification of frame and screen that has dominated much of cinema's history.

Keywords: Virtual Reality, Framing, Spectatorship, Video Games, Media Space

Introduction

A cover story in *Variety* on 22 March 2016 marked a perceived turning point in the emergence of virtual reality (VR), just as the Oculus Rift and HTC Vive headsets were about to be made available to the public. Titled

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'Taking the Plunge', the article featured an illustration depicting three virtual reality users, each wearing opaque goggles and walking blindly toward the edge of a high dive, about to fall into a pixelated abyss (Figure 5.1). The would-be cybernauts, improbably dressed in vintage business attire, are equipped with only old-fashioned inflatable lifesavers to buoy them, and one of these has been lost over the precipice. The playful suggestion was that prospective users of virtual reality were ill-prepared (and improperly suited) for the dangerous waters into which the new screens were about to plunge them. Computer-aided head-mounted displays had, as the article acknowledged, been in existence for almost fifty years, and virtual reality—as both a concept and a technology employed across commercial, military, scientific, and artistic contexts—enjoyed an earlier heyday in the 1980s and 1990s.[2] But the release of the Oculus Rift and HTC Vive, together with the anticipated launch of Sony's Playstation VR headset later in the year, represented, as the article put it, 'the first time that these kinds of devices, capable of delivering immersive VR experiences, are going to make it to consumers' living rooms'.[3] Virtual reality has indeed experienced something of a renaissance since Oculus began shipping prototypes to developers in 2013, as these headsets, alongside more inexpensive devices powered by smartphones, have promised to integrate themselves into a media landscape already characterized by proliferating and pervasive screens.[4] As the *Variety* illustration neatly conveys, this new situation both resuscitates long-standing notions of mediated immersion and suggests that they, like so many of our devices, may require updating.

Taking the recent boom of experimentation with virtual reality as a case study, this essay explores the ways in which contemporary screens are associated with the concept of immersion. These screens often seem to disappear, whether by virtue of their proximity to the eyes (as with virtual-reality headsets) or through their sheer ubiquity and integration with the built environment.[5] Screens, however, continue to contribute materially to the experience of immersion, even (indeed, especially) when they recede from the user's consciousness. Within the immersive *dispositifs* in which the new screens participate, both immersion and screens play particular,

2 Roettgers, p. 31. For histories of virtual reality, see Hillis, 1999 and Grau, 2003. For a detailed nonacademic narrative, see Rheingold, 1991.

3 Roettgers, p. 30.

4 On the reemergence of virtual reality, see Rose, SR5; and Suellentrop, C1.

5 On the idea and history of disappearing technological objects, see Spigel, 2012.

5.1: Depiction of virtual reality accompanied an article titled "Taking the Plunge" Variety, March 22, 2016. Illustration by Daniel Downey. Courtesy of the artist.

historically contingent roles. Specifically, I will argue that these *dispositifs* bind immersive experience to physical space and frame screens themselves as a means of penetrating that space. The notion of plunging—which simultaneously implies falling, penetration, and submersion—will help us map the contours of these formations.

Immersive screens

The concept of immersion, deriving from the Latin *immergĕre* (to dip or plunge), refers to the action of dipping or plunging into a liquid, or of being buried or embedded within another material or space. Figuratively, it extends to the experience of absorption into an action or condition.[6] This concept was widely applied to new digital media in the 1990s—and into the early 2000s—when a range of developments including the rise of computer-aided image creation, interactivity, and multimedial forms were perceived to have transformed images into spaces users could enter,

6 *Oxford English Dictionary Online*, s.vv. 'immersion, n.', 'immerse, v.' Accessed June 4, 2017. http://www.oed.com

experience multisensorily, and intervene upon.[7] Within scholarly discourses at that time, the notion of immersion was bound up with other concepts attributed to new digital media, especially simulation, virtuality, and interactivity.[8] Experimentation with interactive virtual-reality systems, together with a perceived pervasiveness of screens (here gracing devices such as televisions and personal computers), contributed to the notion that people were increasingly plunging into the dematerialized, fabricated realm of 'cyberspace'. In this context, immersion was thus conceptualized in terms of various and contested ideas about how new media were transforming representation, presence, materiality, embodiment, and agency.

Since the early 2000s, as screens have continued to multiply, scholars have challenged the sense of rupture the concept of virtuality had once suggested. In particular, they have historicized 'virtuality' as a concept, emphasized the role the user's body plays in the experience of digital media, and highlighted the materiality of screens themselves.[9] Bound up with those projects, there has also been a significant effort to construct historical genealogies of immersive media. These histories encompass a range of forms, from spaces of illusion (associated with frescoes, panoramas, and certain film and video formats such as Cinerama, Sensorama, and IMAX) to multiscreen and multimedia installations (in the context of fairs and exhibitions, expanded cinema, and experimental work at the juncture of art, performance, and film/video installation).[10] Taken as a whole, this body of work reveals within conceptualizations of immersion faultlines that had been papered over in the 1990s discourses that aligned the term 'immersion' with virtuality, simulation, interactivity, and 'cyberspace'. Although the concepts of presence, illusion, and transparency are routinely employed to define particular forms of immersion, attending to the diverse practices encompassed by these histories makes it clear that such concepts, together with differing ideas about agency and embodiment, come together—or don't—in a variety of ways.[11]

In the remainder of this essay, I will therefore largely bracket the notions of presence, illusion, and transparency that are frequently, if ambiguously,

7 See Murray, 1997; Manovich, 2001; Packer and Jordan, 2001.

8 See Friedberg, 1993; Morse, 1998; Rosen, pp. 338-349.

9 For the effort to historicize virtuality, see Grau, 2003; Friedberg, 2006. On embodiment, see Hansen, 2004. On the materiality of screens, see Straw, 2000; Doane, 2003; Wasson, 2007.

10 See Huhtamo, 1995; Colomina, 2001; Grau, 2003; Marchessault, 2007; Griffiths, 2008; Turner, 2013.

11 I am guided here by Jonathan Sterne's point that concepts such as immersion, high definition, aesthetic pleasure, contemplation, and attention 'have no necessary relationship to one another' and 'can exist in many different possible configurations'. Sterne, p. 5.

associated with immersion and hew closely to the concept's most literal use to indicate a specific kind of spatial relationship between a body and an environment or enveloping substance. This approach, as I hope to show, offers the benefit of revealing connections among practices whose relationships to other concepts often accompanying the notion of immersion, such as illusion, diverge. The spatial relationship between an object and environment implied by the concept of immersion entails (at least) three specific qualities. This relationship is marked, first, by a relative scale. In order to accommodate plunging or embedding, the environment must be construed as larger than the object it is to encompass. Indeed, the capacity to surround, envelop, or enclose—to act, in other words, as a container—is one of the qualities that Susan Stewart attributes to the figure of the gigantic.[12] Second, the notion of immersion implies proximity. Bodies cannot become immersed in a substance or environment from a distance; there must be contact, or the prospect of contact, between a body and its environment. Although we may apprehend a landscape in the distance, for instance, we are only immersed in that landscape if we conceive our bodily space as continuous with it. Thus, the experience of immersion proffered by contemporary virtual reality has been attributed to the sensation that 'there is no distance between you and the environment'.[13] Finally, the concept of immersion suggests a multidimensional relationship. To be immersed, a body must not only come into contact with a larger environment but be surrounded by it.

This formulation of immersion as a particular kind of spatial relationship is especially useful for assessing screen practices, since screens themselves also construct spatial relationships. As an object, a screen supplies means of sheltering, concealing, filtering, partitioning, or revealing spaces (whether actual or virtual); as an action, to screen is, similarly, to protect, conceal, filter, divide, or display.[14] The history of film theory enumerates the varied and often contradictory ways that audiovisual screens mediate virtual and actual spaces; screens function alternately—and sometimes simultaneously—as apertures, thresholds, barriers, masks, frames, mirrors, and skins.[15] Screens' material qualities contribute to these functions in a variety of ways. The screen's borders work to enclose, obscure, reveal, or demarcate the spaces within and surrounding its edges, enabling the screen to function as a

12 Stewart, p. 71.

13 Lelyveld, p. 78.

14 *Oxford English Dictionary Online*, s.vv. 'screen, n.', 'screen, v'. See also Huhtamo, 2004; Friedberg, 2006; Acland, 2012; Verhoeff, 2012; Bruno, 2014; Casetti, pp. 155-178.

15 Sobchack, pp. 14-17; Friedberg, 2006, pp. 15-18; Casetti, pp. 157-169.

frame, mask, aperture, or connector. Factors contributing to those functions include the scale and shape of the screen, the rigidity or flexibility of its boundaries, and its proximity to the beholder. The screen's surface enables it to function as a threshold, barrier, reflector, membrane, interface, or vehicle for light and sound, thus joining, separating, or reconfiguring the spaces in front of and behind it. Factors contributing to those functions include the screen's transparency, texture, and material composition. Additionally, the mobility of screens, achieved through their capacity to both move and display movement, renders these spatial mediations fluid and dynamic.

There are many ways in which these material qualities can be harnessed, together with particular types of representation, to form the relationships of scale, proximity, and multidimensionality facilitating immersion. Indeed, we can chart the flexibility and historical contingency of the notion and experience of immersive screens by mapping the diachronic and synchronic permutations of such *dispositifs*. Delineating these formations provides insight into conceptualizations of mediated environments—and bodies' relationships to them—in particular historical contexts. At the same time, it highlights screens' diverse and protean roles in structuring those environments and relationships. In what follows, I will explore one such formation, looking closely at contemporary uses of virtual-reality headsets.

Plunging into virtual reality

The term 'virtual reality' was reportedly coined by the computer scientist and entrepreneur Jaron Lanier in 1989, but this concept drew on, and drew together, an array of more long-standing ideas and achievements.[16] By the late 1980s, key components of the technological assemblage that would come to be associated most strongly with virtual reality—a head-mounted display (HMD) paired with computers and input devices such as data gloves or controllers—had been in existence for decades.[17] Despite virtual reality's eventual association with forms of commercial entertainment such as video games, much of the development of this technology took place in academic and military research laboratories as well as in commercial laboratories focused on industrial applications, with projects ranging from flight and weapons simulators to scientific visualization, surgical training, and architectural walkthroughs.

16 Krueger, p. xiii.

17 See Biocca, 1992.

For instance, Ivan Sutherland, working at MIT and then the University of Utah with funding from the Advanced Research Projects Agency (ARPA) and the Office of Naval Research, developed and refined a computer-aided HMD in the late 1960s and early 1970s. Nicknamed the 'Sword of Damocles', the device employed two small cathode ray tubes (CRTs) and a series of lenses and half-silvered mirrors to project 3D computer graphics (depicting objects such as cubes and molecular models) 14 inches in front of the user, hovering within the actual environment and thus functioning more as augmented than virtual reality. The system tracked the position of the user's head and updated the visual display to correspond with its changing perspective.[18] Claiming to have been stimulated by Sutherland's writing—specifically his 1965 essay, 'The Ultimate Display', which conceptualizes a multisensory encounter of virtual worlds—researchers at the University of North Carolina, led by Frederick Brooks, Jr., were by the late 1960s experimenting with the use of haptic feedback in conjunction with visual displays, particularly as a tool for scientific visualization.[19] Research at the U.S. Air Force, led by Tom Furness, had focused on visual displays for cockpits since 1966; in 1982, Furness and his colleagues introduced the Visually Coupled Airborne Systems Simulator (VCASS), which featured a helmet that employed miniature CRTs and mirrors to display computer-generated maps of the landscape synchronized with radar information. Later iterations, eventually under the aegis of the Super Cockpit program, included eye tracking, voice command, 3D sound, tactile gloves, and new helmets which used half-silvered mirrors to overlay graphics on the actual cockpit.[20] In the mid- to late 1980s, researchers at NASA's Ames Research Center—including Scott Fisher, who had been involved with interactive displays at MIT in the late 1970s and worked at Atari in the early 1980s—developed the Virtual Environment Display (VIVED) and then the Virtual Interface Environment Workstation (VIEW) systems. Both systems employed HMDs with stereoscopic displays and allowed for input not only through position tracking but also through gesture, thanks to the incorporation of the data glove developed by Fisher's former Atari colleague Thomas Zimmerman (who had since teamed up with Lanier, another Atari alumnus, to form the commercial firm VPL Research). The VIEW system also provided 3D sound and speech recognition.[21]

18 Rheingold, pp. 104-109.

19 Ibid., pp. 20-21, 37-43. See also Brooks, Jr. et al., 1990; Sutherland, 2001.

20 Rheingold, pp. 205-208.

21 Ibid., pp. 128, 131-154. See also Fisher, 2001.

In uniting various academic, military, and commercial projects undertaken in the preceding decades, the notion of virtual reality identified what was taken to be an emerging form of mediated experience. Although the term has long conjured the HMD-centred technological assemblages described above, by the early to mid-1990s it was conceptualized more broadly in terms of the experience of presence in mediated spaces. In particular, it was taken to denote simulated environments that functioned as if authentic by proffering the experience of presence. In some formulations, the notion of virtual reality could also encompass the mediated perception of temporally or spatially distant actual environments via the concept of 'telepresence'.[22] As Jonathan Steuer argued at the time, virtual-reality systems sought to evoke the sensation of presence in artificial or distant spaces through a combination of sensory breadth (a multisensory address), sensory depth (resolution), and interactivity (understood as the user's capacity to modify the mediated environment).[23] The concept of virtual reality thus encompassed technological configurations beyond the 'goggles and gloves' arrangement, including physical installations such as the 'responsive environments' that Myron Krueger developed in the 1970s and the Cave Automatic Virtual Environment (CAVE) that Daniel Sandin, Thomas DeFanti, and Carolina Cruz-Neira created in 1991.[24] The interest in interactive simulated environments and mediated presence was, to be sure, bound up with developments in computing as well as cultural responses to them, especially William Gibson's 1984 science-fiction novel *Neuromancer*, which popularized the term 'cyberspace'. But it also drew on other recent trends—including immersive film and video formats such as Cinerama and Sensorama as well as practices in art and performance—which harnessed various configurations of multisensory address, high resolution, and spectator engagement.[25]

In bringing together this range of practices through the alignment of immersion with presence, the notion of virtual reality as it was conceptualized in the 1990s thus downplayed the significant material differences among various technological arrangements, including the use of screens with dramatically divergent sizes and levels of mobility. In doing so, it upheld the emphasis on dematerialization associated with virtuality generally. In line with my effort to parse particular immersive *dispositifs*, the analysis

22 See Steuer, 1992.

23 Ibid., pp. 81-86.

24 Krueger, pp. 12-64. See also Sandin, DeFanti, and Cruz-Neira, 2001.

25 See, for instance, Fisher, 260-261; and Krueger, 6-8.

I undertake here, by contrast, focuses on the conjunction of a particular technological arrangement and form of representation. Specifically, I examine how the visual logic associated with spectacles of airborne action—a mainstay of immersive cinema formats—operates in conjunction with contemporary virtual-reality headsets. Attending to the persistence of such spectacles across media makes it possible to chart how the small, mobile screens gracing the new headsets transform the relationship between users' bodies and their environments. Doing so thereby reveals how practices associated with the new virtual-reality screens reframe the experience of immersion.

In adopting certain imagery, contemporary commercial applications of virtual reality seem to reiterate the means by which other media have exploited and flaunted their immersive nature. Consider, for instance, the virtual-reality video game *The Climb* (Crytek, 2016), which positions the player in a series of exotic mountainous landscapes (Figure 5.2). The game has the player attempt to scale the steep edifices only to plummet upon misplacing her grip. As with a film such as *Avatar* (James Cameron, 2009), whose visual style the game recalls, *The Climb* thus harnesses a supposedly (but not actually) new immersive technology, together with digital imaging, both to plunge users into a spectacular space and to provide the visceral experience of plunging through that space.[26] In employing virtual reality to engulf players in awe-inspiring realms, *The Climb* falls in line with a range of older immersive forms, from cathedrals to panoramas.[27] In its focus on provoking the sensation of movement through such realms, it aligns itself especially closely with immersive cinema formats such as Cinéorama, Vitarama, Cinerama, 3D, and IMAX, as well as flight simulators, which have long harnessed the spectacle of aerial motion in particular to display the technologies' capacity not only seemingly to position viewers high above the earth but also to provide a visceral experience of kinesis.[28] In virtual reality, as in these cinema formats, immersive screens contribute to the experience of kinesis by provoking the visual sensation of motion despite the user's or viewer's simultaneous felt experience of bodily stasis.

Such aerial spectacles have also become a prominent component of contemporary blockbuster movies employing digital visual effects, often in conjunction with immersive exhibition formats such as 3D and IMAX. As Kristen Whissel argues, such spectacles shift emphasis away from the

26 See Ross (Miriam), 2012; Rogers, 2013, pp. 210-222.

27 See Grau, pp. 56-139; Griffiths, pp. 15-78.

28 See Belton, 1992; Huhtamo, 1995; Griffiths, pp. 79-113; Ross (Sara), 2012; Taylor, 2013.

5.2: The virtual-reality video game *The Climb* has players ascend to vertiginous heights. *The Climb* 2016 Crytek GmbH. All rights reserved.

screen's *x* axis and toward its *y* and *z* axes, producing what she identifies as a 'new verticality', which exploits the capacity of visual effects to create spectacles that defy the laws of physics. In emphasizing descent and ascent within the frame—and foregrounding the pull of gravity and its defiance within the diegesis—such spectacles dramatize a range of polar oppositions relevant to global audiences and mark moments of temporal rupture and historical transition within and surrounding the films.[29] Especially insofar as many films and games being produced for virtual reality also make use of digital imaging, they are particularly closely aligned with recent films such as *Avatar* and *Gravity* (Alfonso Cuarón, 2013), which employ both immersive exhibition formats and computer-generated imagery to supply the sensation that viewers are defying gravity by flying or hovering in aerial environments alongside the characters.[30] Such works thus exemplify how the visual logic of verticality (if not necessarily its narrative function as what Whissel calls an 'effects emblem') traverses a range of forms, as she argues, aligning virtual reality with cinema, gaming, and comics.[31]

Virtual-reality headsets, however, transform the way screens collaborate with such spectacles to elicit immersion. Film formats have historically achieved their claim to immersivity by virtue of the scale—and sometimes

29 Whissel, 2014, pp. 21-58.

30 See Richmond, pp. 121-143; Whissel, 2016.

31 Whissel, 2014, p. 21.

also the curvature—of the screen, often together with the employment of high-resolution and/or three-dimensional images and surround sound systems. Not only does a large scale enable screens to function as environments but it also collaborates with other components of exhibition and representation to facilitate the perception of continuity between actual and depicted space, suggesting the extensiveness of the represented realm as well as the viewer's proximity to it.[32] Virtual-reality headsets, by contrast, push the boundaries of the screen frame beyond the viewer's field of vision not by virtue of the screen's scale but rather through its proximity to the eyes. By virtue of this arrangement, virtual-reality headsets emulate other 'peeping' devices such as stereoscopes, kinetoscopes, or—anticipating the connection to x-rays I will make later—certain early fluoroscopes.[33] Contemporary virtual-reality headsets, we might note, can incorporate either dual screens (one screen for each eye) or a single screen divided into two images (one image for each eye). As with 3D cinema, the use of stereoscopy facilitates a sense of continuity between the bodily space of the viewer and the represented imagery. Although the screens themselves do not possess the immense scale necessary to engulf viewers, virtual-reality headsets can proffer a sense of vastness and depth through the representation of environments. They do so not only by depicting the environments' extension into the distance but also by rendering their extensiveness multidirectional so that the viewer understands their reach only over time through exploration.[34]

This arrangement transforms the construction of verticality, including the portrayal of aerial spectacles, and alters the forms of experience it elicits. With cinema, verticality is conveyed representationally (with relation to the depicted world) and graphically (with relation to the frame of the screen). These two forms of verticality often coincide, as when a figure leaping from a tall building in the diegesis also moves down along the *y* axis in the frame. But they can also diverge, as in the shot of L.B. Jeffries (James Stewart) falling out of the eponymous aperture in *Rear Window* (Alfred Hitchcock, 1954), where the high-angle view of the falling figure exploits *z* axis movement. Moving-camera shots depicting the action of falling or diving can also exploit the *z* axis, as when the camera is mounted at the front of a plunging roller coaster in *This Is Cinerama* (Merian C. Cooper, 1952). Significantly,

32 See Rogers, 2016.

33 See Huhtamo, 2012.

34 See Susan Stewart's discussion of the gigantic as something we know 'only partially'. Stewart, p. 71.

however, in a traditional cinematic arrangement the vertical orientation of the screen itself remains steadfast in all of these cases, matching the upright orientation of the heads and bodies of seated viewers. Even when the onscreen depiction of vertical movement diverges from the vertical orientation of the screen, as with the depiction of a descent that moves along the *z* axis, the screen's position persists in grounding that depiction, providing it a particular situation in actual space. Such instances of disjuncture in orientation provoke the form of pleasure that Scott Richmond attributes to conflict between the viewer's visual and vestibular senses—for example, by making it look as though one is horizontal to the earth when one also feels oneself sitting upright—especially when portrayed on large screens, which allow the spectacle to fill the viewer's field of vision.[35]

Contemporary employments of virtual reality also emphasize verticality representationally, as *The Climb* exemplifies. The animated virtual-reality film *Allumette* (Eugene Chung, 2016) also takes place in an aerial environment and articulates danger and redemption in terms of descent and ascent within that space. In this case, the viewer hovers alongside the characters, capable of looking up into the sky and down into the atmospheric depths. The prospect of catastrophe emerges when a burning ship threatens to fall onto a crowd gathered below (Figure 5.3). The protagonist's mother averts that disaster, sacrificing herself in the process, by boarding the ship and steering it high into the sky, where it finally explodes, raining embers. The virtual-reality film *Take Flight* (Daniel Askill, 2015), like *The Climb*, proffers the experience of vertical motion, here through the portrayal of an ascent. In this case, the viewer's perspective begins on a city street, only to rise quickly through the skyscrapers to a space above the clouds where that perspective hovers alongside several floating celebrities.

Despite these connections, such spectacles, as they are presented through contemporary virtual-reality headsets, diverge from cinema by divorcing vertical articulation from the frame of the screen and establishing it instead in relation to the user's body as it is oriented and positioned in space. Since the screen is now affixed to the user's face and mounted on the axis of her neck, screen space can appear not only to ring her body panoramically but also to exist above and below her head. Indeed, the capacity to present mediated space above and below the user's head represents a prevalent preoccupation of the films and games produced for the new systems. While the experience is similar to having a screen on the ceiling of a small exhibition space, it is different from having a screen on the floor (as in the CAVE

35 Richmond, pp. 134-135.

5.3: In the virtual-reality film *Allumette* (Penrose Studios, 2016), the prospect of catastrophe emerges when a burning ship threatens to fall onto a crowd gathered below.

system) since mediated space now rises to the level of the user's face, even in the place where she feels her body to be. Many virtual-reality applications portray the space below the user's head as empty, so that in looking down toward one's own body one instead sees vacant diegetic space. However, some examples, such as the virtual-reality film *Invasion!* (Eric Darnell, 2016), present animated bodies in the space below the user's neck. Others can make it seem as though the user is up to her neck in components of the setting: for example, the virtual-reality film *Dear Angelica* (Saschka

Unseld, 2017) allows the viewer's visual perspective to hover just above the surface of a represented bed so that her felt body seems buried inside the mattress, and the virtual-reality application *The Night Café* (Mac Cauley, 2015) makes it possible for the user to embed herself up to the neck in a represented bar counter.

The availability of mediated space above and below the head not only further enables represented space to surround the user but imbricates that gesture with the articulation of verticality. With *Allumette*, for instance, the looming catastrophe is only visible if the viewer looks down to below the place where she feels her body to be. *Take Flight* enables the viewer to watch the city recede in that space. And *The Climb* conveys how far the player has ascended—and how far she has to fall—by depicting the depth below her. Other virtual-reality applications emphasize verticality through the depiction of objects descending from above. Both *Invasion!* and the virtual-reality game *Trials of Tatooine* (Lucasfilm, 2016), for instance, feature spaceships that seem poised to land on top of the user. The virtual-reality film *Colosse* (Fire Panda, 2015) depicts a looming creature. Both *Invasion!* and *Colosse* alert the user to these overhead threats by having small characters run around and hide behind her, looking up in fear. Taking a cue from these characters, the user also cranes her neck and looks up in order to see the ship or creature approaching from above. In such cases, verticality is not relative to the screen nor to the user's head but rather to the remainder of her body and her experience of gravity. In other words, although the depicted ship and creature appear to move forward on the *z* axis relative to the user's face, their motion is perceived as a descent because it travels along the *y* axis relative to her torso and felt position on earth.

Underlying this shift in the articulation of verticality is a transformation in the relationship between the user's body, the screen, and represented space. With cinema, the space that appears onscreen—whether diegetic or graphic, representational or abstract, static or moving—bears a stable relationship to the screen itself. Neither movement of the screen nor the position of the viewer affects that relationship. The screen may incorporate multiple images as with split screen, and its dimensions may change as with the Magnascope system of the 1920s.[36] But even in such cases the screen continues, if dynamically, to operate as what Stephen Heath describes as both receiver and provider of the frame. As Heath puts it, the screen's alignment with the frame is 'the basis of the spatial articulations a film

36 On split screen, see Friedberg, 2006, pp. 199-206. On Magnascope, see Belton, pp. 36-38.

will make, the start of its composition'.[37] With virtual-reality headsets, screens continue to give support to images, but they no longer anchor spatial articulation. Instead, space is articulated through the mapping of orientation, position, and movement across actual and virtual realms.[38] It is this mapping itself that remains stable (if the system is functioning according to design), enabling the screen's relationship to represented space to become volatile. Hence movement of the screen, propelled by the user's movement, results in onscreen transformation. While no movement of the film screen or viewer will alter James Stewart's position in the frame in *Rear Window*, the positions of onscreen elements in *The Climb* shift as the player does—if she moves her head to look down, the screen image shifts accordingly to provide a vertiginous, high-angle view.

In permitting and emphasizing the correspondence of such movements, films and games produced for virtual reality alter the relationship between represented and actual space. The works I have discussed map the orientation, position, and movement of the user's head onto the orientation, position, and movement of the visual perspective supplied by a virtual camera. As with the earlier use of HMDs such as Sutherland's 'Sword of Damocles', the new systems achieve this mapping through a process that involves tracking the user within actual space and updating the image display accordingly. Oculus Rift headsets, for instance, contain motion and position sensors (gyroscopes, accelerometers, and magnetometers) that work together to track the orientation of the user's head. The headsets also contain infrared LEDs that function in connection with external infrared cameras to track the user's position in space. Dynamic information on the orientation and position of the headset in actual space is, in turn, employed to orient, position, and move the field of view within a virtual environment.[39] Despite the fact that represented space has been untethered from the screen, it has not become unmoored. The employment of tracking systems—which measure movement not only in relation to the user's previous orientation and position but also in relation to external forces (e.g., gravity) and reference points (e.g., the infrared camera)—ties representation even more firmly to actual space.[40]

37 Heath, p. 393.

38 On the significance of such mapping for the development and operation of virtual-reality technologies, see Biocca, p. 27, pp. 49-56; Steuer, pp. 86-87.

39 See the discussion of Oculus's tracking system in its outline of best practices for developers, online at https://developer.oculus.com/design/latest/concepts/bp_app_tracking (accessed June 5, 2017).

40 Stanković, pp. 92-97.

In response to the notion that virtual reality enables users to escape their bodies, scholars have long emphasized how it activates and indeed relies upon users' bodies.[41] Although my observations about the exploitation of verticality support that argument, they also make a further point. Far from tools for dematerialization, these applications of virtual reality rematerialize representation by anchoring it not only to users' bodies as they interact with virtual environments but also to the users' physical environment.[42] Through the use of tracking systems, onscreen representation is made to index the orientation and position of the user's body in actual space. The user's experience of represented space is also tied to actual space, especially in the exploitation of verticality, since it relies on her capacity to gauge up and down proprioceptively, a capacity that is anchored to the earth in part through the way gravity acts on the musculature and inner ear.[43] When an upright viewer sees James Stewart fall in *Rear Window*, his movement along the *z* axis conflicts with her own bodily experience of space, but with *Allumette* the act of looking down to see the threatened townspeople is grounded in the user's bodily position and experience.

As applied to illusionistic media such as virtual reality, immersion is often described as the experience of being 'in the picture'.[44] This experience is frequently conceptualized as a movement into another space. For instance, Mel Slater and Sylvia Wilbur contend that the 'grand aim of immersive virtual environments research is to be able to realize that same "stepping through the glass" or "rolling down the window" with respect to computer-generated environments as can be experienced when stepping through a barrier that in normal circumstances screens some aspect of reality from us.'[45] Other conceptualizations of immersion—especially those addressing the multiple-screen displays associated with expanded cinema, video art, and the historical avant-garde—describe screens as components of an architecture that surrounds the viewer, allowing screen space to shape actual space.[46] The contemporary applications of virtual reality that I have discussed, however, neither evoke the experience of movement into different spaces nor operate as architectures forming new spaces. Rather, they

41 Huhtamo, 1995, pp. 176-177; Hansen, 2004, pp. 161-196. For a more recent discussion, see Popat, 2016.

42 For an argument about the imbrications of body and environment in virtual reality, focusing on the body's relation to virtual environments, see Hansen, 2001.

43 Richmond, pp. 6-9, 134-135.

44 Grau, p. 141. Also see, for instance, Belton, p. 98; Lelyveld, p. 78.

45 Slater and Wilbur, p. 604.

46 See, for instance, Marchessault, p. 39.

immerse users in a familiar, worldly space imbricated with representation. This formulation may recall descriptions of 'cyberspace' as an immaterial realm that substitutes for the material world, but I am suggesting something different. These applications of virtual reality spectacularize the forms of connection and tracking that enable the user's felt experience of the world to drive representation. In doing so, they are exposing phenomena (forms of connection and tracking) that constantly surround us but often remain invisible. Far from displacing the material world, these uses of virtual reality, in short, penetrate its surface.

Penetrating screens

Against the tendency to contrast illusionistic and non-illusionistic screen practices, this formulation of immersion aligns the experiences provided by contemporary applications of virtual reality with those associated with the proliferation of screens more broadly. As Francesco Casetti has argued, contemporary proliferating screens function as 'junctions of a complex circuit, characterized both by a continuous flow and by localized processes of configuration or reconfiguration of circulating images'.[47] As a result, we find ourselves immersed, as he contends, within the circulation of information.[48] As our interfaces to technological, social, political, and economic networks, screens operate as interlinked nodes in constantly changing formations. Although the screens themselves may be small, these formations are so boundless and complex that they bear comparison to the sublime.[49] In this context, our proximity to a range of screens (especially those we wear or hold in our hands), in conjunction with the sheer scale of the networks to which they connect us, provokes experiences of immersion. Like other spaces of immersion—such as the panoramas of the nineteenth century and the multiscreen displays of the twentieth—the networks of the twenty-first century, as many have argued, are not only sites of apparent agency but also, increasingly and pervasively, means of control and capture.[50]

At roughly the same time as the resurgence of virtual reality, there has also been a swell of interest in practices that exploit the proliferation of screens by encouraging simultaneous engagement with multiple screens. Some of these

47 Casetti, p. 156.
48 Ibid., p. 170.
49 For a discussion of this comparison, see Jagoda, pp. 20-21.
50 For a gloss on these ideas, see Galloway, 2010.

map the screens' relationships to actual space and to one another, as with *KL Dartboard* and *Darts* for iPad and iPhone (2010), which enabled players to launch virtual projectiles from phone to tablet.[51] With others, screens' relationship to one another is more informational than explicitly spatial, as with 'second-screen' applications tied to television broadcasts.[52] Such multiscreen practices, like the virtual-reality practices I have discussed, manifest the screen's relation to other devices (e.g., through network connections) and to physical space (e.g., through the use of sensors and location tracking). In doing so, they also make visible the often hidden but nevertheless constant connections among our devices as well as the often hidden but materially and geographically situated infrastructures supporting them.[53] Multiscreen practices reveal such connections and infrastructures by materializing particular, though fleeting, configurations, thus providing users a (small) point of access to the vast and dynamic networks that pervade our environment yet, as Patrick Jagoda puts it, remain 'accessible only at the edge of our sensibilities'.[54]

In making such hidden connections and structures visible, these screens do not function as apertures, thresholds, or components of architecture but rather as a means of penetration. In this regard, they are aligned less closely with objects such as windows, doors, or walls than with devices such as probes, x-rays, and scanners.[55] Upon their discovery at the end of the nineteenth century, x-rays presented the possibility of rendering the invisible visible by penetrating the body and revealing the skeleton, offering a form of 'penetrating vision' that was considered both macabre and erotic.[56] In the second decade of the twenty-first century, a different kind of penetrating vision is revealing a different kind of skeleton. In this case, however, our bodies do not contain that framework; rather, it contains us. Whereas x-rays provided a means of plunging into the body, the new screens uncover structures underpinning a space in which we already find ourselves immersed.

This conceptualization of contemporary screen practices suggests a genealogy of immersive screens, supplementing those that trace concepts such as illusion and presence, tied instead to the notion of penetration. The idea of penetration highlights the way in which immersion arises in

51 See Levin, 2014.

52 See Holt and Sanson, 2014.

53 See Chun and Friedland, 2015; Starosielski, 2015.

54 Jagoda, p. 3.

55 Thomas Elsaesser has similarly argued that attention to imaging practices (especially 3D) in realms such as the military frames contemporary imaging technologies as 'technologies of probing and penetration'. Elsaesser, p. 242.

56 Cartwright, p. 111; Tsivian, p. 82.

and through the act of plunging, an act that entails not only entry into an environment but also the formation of an environment as such. An attunement to the idea of penetration, for one thing, re-centres the close historical proximity between the film screen and the x-ray screen at the time of their mutual emergence, highlighting their shared application to the transgression and reconfiguration of spaces. (Although the term 'x-ray' often conjures photographically fixed images, Wilhelm Conrad Röntgen's initial x-ray apparatus of 1895 employed a screen, as did the fluoroscopes that Thomas Edison and others had developed by 1896.)[57] Indeed, cinema was what Tom Gunning has described as a 'sister technology' of the x-ray, presented in its earliest years as a similar kind of technological wonder.[58] And, as scholars such as Lisa Cartwright and Yuri Tsivian have shown, the forms of visuality proffered by x-rays and cinema were intertwined, especially via what Tsivian identifies as a shared investment in the principle of penetrating vision.[59] In proffering entry into the bodily interior, x-rays crossed the boundary marked by the skin and, concomitantly, reconfigured the relationship between the interior and exterior. Insofar as this form of penetrating vision offered access to invisible realities and conjured spatial reorganizations via transparency, it was, like the new mode of vision offered by cinema, as several scholars have argued, bound up with the spatial reconfigurations associated with modernism and modernity more broadly.[60]

The concept of penetration, moreover, reveals how the spatial transgressions that screens achieve have themselves taken up and reconfigured other practices. Perhaps most notably, an investment in penetrating vision also characterized the form of medical perception that, as Michel Foucault contends, emerged around the turn of the nineteenth century in conjunction with the embrace of practices such as dissection.[61] In this context, the use of the scalpel contributed to what Foucault describes as the emergence of a modern conception of the bodily interior as a perceptible space: as a means of penetrating into the depth of the body, the scalpel, as he puts it, rediscovered 'organic space'.[62] Insofar as x-rays also permitted penetration of the body and inspection of the interior, they thus took over medical functions that were previously associated primarily with cutting

57 Glasser, pp. 3-5, 233-243; Curtis, p. 239.
58 Gunning, 1994, p. 196; Gunning, 1990, p. 58.
59 Tsivian, p. 82. Also see Cartwright, pp. 107-142.
60 See Henderson, 1988; Gunning, 1997.
61 See Foucault, 1994.
62 Foucault, p. 141.

it open.[63] Walter Benjamin famously described cinema's achievement of spatial reconfiguration with reference to a similar form of penetration through incision. Likening the camera operator to a surgeon, he argued that the 'cinematographer penetrates deeply into [the] tissue' of reality in order to assemble its parts anew.[64] Mapping these connections allows us to recognize the ways in which the screen itself has also operated as a tool not only for visualization but also for cutting, akin not only to medical imaging technologies but also to more long-standing means of bodily penetration, especially the scalpel. Indeed, like the scalpel, as well as the editor's splicer, both the surface and the frame of the screen at once sever spatial entities and create new spatial junctions.[65]

In connection with virtual reality's medical applications, HMDs were, early on, conceived—perhaps only half-jokingly—as 'x-ray glasses'.[66] This association frames certain HMD screens not only as technologies of vision but also as a means of peeling back the surface of the body and entering its interior. As I have argued, many contemporary screen practices, from the new virtual-reality systems to smartphones more generally, conduct a similar operation on the space of everyday experience. While the scalpel and the x-ray simultaneously plumbed and constructed bodily space as a penetrable depth, these new screen practices both expose and actualize the expansiveness of the mediated space surrounding us.

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63 Van Dijck, p. 4. Also see Cartwright's discussion of medical transillumination practices employing endoscopic devices. Cartwright, p. 113.

64 Benjamin, III, p. 35.

65 Also see Friedberg's contention that the screen frame marks an 'ontological cut' between 'the material surface of the wall and the view contained within the frame's aperture'. Friedberg, 2006, p. 157.

66 Rheingold, pp. 22, 33.

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