Introduction: Designing Mixed Reality

An emerging generation of artists is turning to digital technologies to fundamentally transform theater. At the same time, by collaborating with technologists, they are also reshaping the nature of human interaction with computers. Working at the cutting edge of live performance, these artists are increasingly employing digital technologies to create distinctive forms of interactive, distributed, and often deeply subjective theatrical performance. Although early examples are diverse in their detail, they share important underlying characteristics, in that they establish complex relationships between multiple physical and virtual spaces; employ networking to create distributed structures that flexibly interconnect many local settings to create a global "stage"; integrate live performance by actors and audiences with digital media and the kinds of rule-based structures that are found in computer games; and establish rich temporal structures in which the artistic experience is interwoven with ongoing everyday activities. We refer to these experiences as *mixed reality performances*, a term that is intended to expresses both their mixing of the real and virtual as well as their combination of live performance and interactivity.

This book charts this new field of practice by documenting landmark examples of mixed reality performance while recording interviews with key practitioners, both artists and technologists. It then draws on this material to develop an overarching theory to guide the future study and design of mixed reality performance. The foundation of this theory is that we can express how artists design, and participants experience, mixed reality performance in terms of multiple interleaved trajectories through complex hybrid structures of space, time, interfaces, and roles that establish new configurations of real and virtual, local and global, fact and fiction, personal and collective.

We follow an interdisciplinary approach that draws generally on the humanities, computer science and social science, and specifically on the fields of human-computer interaction (HCI) and performance studies which are the backgrounds of the two authors. In its detail, the book draws on a series of works that have been codeveloped by the Mixed Reality Laboratory (MRL) at Nottingham in collaboration with a series

of artists, most notably Blast Theory. Indeed, a further outcome of the book is to document the series of collaborations between the Mixed Reality Laboratory and Blast Theory that for more than a decade have gradually evolved a distinctive interdisciplinary approach to combining practice with research. Studies of individual works and elements of our theory of trajectories have previously appeared in various papers in sources such as the Association for Computing Machinery's (ACM's) annual conference on Human Factors in Computing Systems (CHI) conference and more recently in humanities journals such as *Contemporary Theater Review*, *Leonardo*, and *PAJ*. Our book draws this material together for the first time to present a comprehensive and extended account of the works, studies, and theories from multiple perspectives. This introductory chapter provides the general background to our study of mixed reality performance, covering

- the definition of mixed reality performance in relation to the wider fields of mixed reality and performance;
- an overview of our methodology, both in terms of wider contributing disciplines but also a brief history of how the Mixed Reality Laboratory has evolved its particular approach;
- an introduction to the foundational concept of trajectories that underpins our theory as seen from different disciplinary perspectives;
- a guide to the structure of our argument and of subsequent chapters.

Mixed Reality Performance

Mixed reality performance might simply be defined as the staging of theatrical performances in mixed reality environments. A more sophisticated and useful definition than this requires us to explore in some depth what we mean by both mixed reality and performance.

On the Nature of Mixed Reality

Beginning with mixed reality and turning first to computer science, an ideal starting point is Paul Milgram and Furnio Kishino's taxonomy of mixed reality displays, which includes the "virtuality continuum" as covering a spectrum of different forms of mixed reality from purely physical, real environments at one extreme to purely virtual environments at the other (see figure 0.1). In between these two extremes lie augmented reality, which signifies physical environments that are overlaid with digital information, and on the other side, augmented virtuality, in which virtual environments are overlaid with physical information (Milgram and Kishino 1994). A good example of the former is Wikitude, which allows via geotagging the augmentation of physical spaces through digital information, and a characteristic example of the latter is

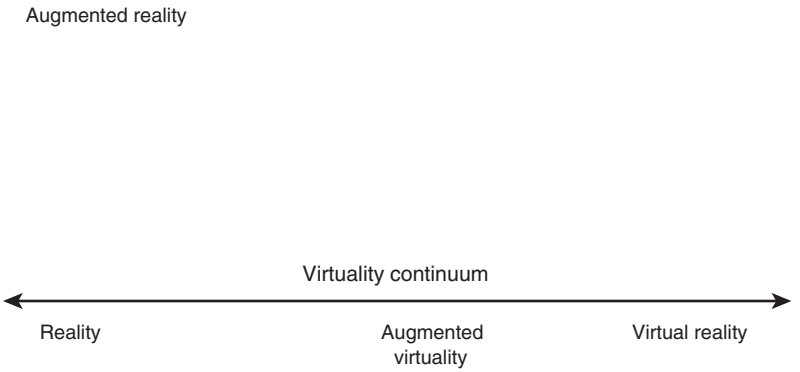

Figure 0.1
Milgram and Kishino's Mixed Reality Continuum.
Drawn by Steve Benford.

enhancing virtual environments such as Second Life with video views and other live information from the real world.

What is interesting about this framework is that it encompasses both "real" and "virtual" elements and so allows for the possibility of generating and analyzing environments in which physical and digital objects cohabit and interact in real time. We shall see many times in this book how mixed reality performances may simultaneously occupy multiple points along this continuum by combining many real, virtual, augmented reality, and augmented virtuality environments into complex hybrid and distributed performance stages. This combination may certainly involve overlaying real and virtual environments, but may also involve other spatial relationships, such as making them adjacent so that participants can look or even pass from one to the other. The idea of adjacent rather than overlaid real and virtual spaces is explored in Boriana Koleva's study of traversable interfaces, which shows how such environments may spill onto one another but remain seemingly separate from one another even when forming part of the same mixed reality environment (Koleva et al. 2000). So whereas the virtuality continuum remains a useful means to understand the broad relationship between reality and virtuality, a more rhizomatic model would allow for the real and virtual to be overlaid or juxtaposed rather than opposed to one another. Indeed, Milgram and Kishino's original taxonomy itself argues for a more sophisticated classification of mixed reality environments based upon multiple dimensions of "extent of world knowledge," "reproduction fidelity," and "extent of presence metaphor" (1994).

Many of the performances that we consider in this book involve using mobile technologies to enable spatially extended performances, or embedding computer

interfaces into everyday artifacts and structures, which naturally leads us to the idea of ubiquitous computing (ubicomp), one of the most significant ideas to emerge from computer science in the last twenty years. In his seminal essay "The Computer for the Twenty-First Century," Mark Weiser talked about "embodied virtuality," as "the phenomenon by which the 'virtuality' of computer-readable data—all the different ways in which it can be altered, processed and analyzed—is brought into the physical world" (1991, 20). Computers, he stated, will become "invisible" and will be "interconnected in a ubiquitous network" (20). In this context, he predicts, people will use computers "unconsciously to accomplish everyday tasks" (21). This vision of ubiquitous computing is seen as a direct contrast to, and even rejection of, the earlier vision of virtual reality. Ubiquity and immersion could thus be seen as two opposing forces that point to opposing ends of the virtuality continuum. However, the mixed reality performances that we consider in this book appear to comfortably combine the two, with participants sharing or contrasting perspectives between them or moving from one to the other during a temporally extended performance. In short, mixed reality performances deliberately adopt hybrid forms that combine the real and virtual in multiple ways and through this, encourage multiple and shifting viewpoints. Ten years after Weiser's essay, Jay David Bolter and Richard Grusin discuss how ubiquitous computing is turning "our whole world into a computer interface" (2000, 213). Whereas virtual reality immerses the user into a simulation, ubiquitous computing, they note, offers a world in which "everything is a medium because everything is or contains a computing device" (217). Here, they claim, "the question of the subject does not need to arise, because with ubiquitous computing, we do not have to occupy different points of view" (219). In this book, we show the opposite, which is that the question of the subject must arise in ubiquitous computing precisely because different points of view can be occupied, so the subject's way of experiencing this new mixed reality is always already based on the convergence, divergence, and reconvergence of multiple embedded and emergent trajectories. It is by adopting different positions on these trajectories that the subject can remain empowered in this new world, so aptly described by Weiser, in which real and virtual are continuously intersecting one another.

In whichever case, the essentially hybrid nature of the environment generated by the coexistence or superimposition of real and virtual merits further analysis. Here, studies of installations, performances, and games from the humanities shed further light. So, for instance, in his study of "virtual art" Oliver Grau dedicates a section to mixed reality in which he identifies the fact that users do not need to wear "oppressively heavy HMD" and are "not forced into the computer-generated body of an avatar" (2003, 245) and identifies hybridity as a distinctive characteristic of this type of space. In writing about Monika Fleischmann and Wolfgang Strauss's *Murmuring Fields* (1998), developed as part of eRENA, an EU-funded project that also involved

the Mixed Reality Laboratory, Grau then notes how the work attempted to construct a "hybrid" space, a "combination of projection screen and viewing room, which does not alienate the observers from their own physical perception" (245). Distinctively, he also cites Strauss noting its aim was to emphasize "the body and its materiality and integrate its dynamics into virtual action spaces" (Strauss in Grau 2003). Unlike virtual reality, mixed reality in fact offers the possibility of creating such hybrid performative and participatory environments in which real and physical data appear, but not so much as integrated into one another but rather juxtaposed on top of or next to each other. Here, we aim to analyze how to design and manage these particular types of hybrid environments.

A number of other works developed over the last ten years distinctively blurred the boundaries between virtual and real. A popular example is *Majestic* (2001), a commercial alternate reality game reminiscent of the serial *The X Files* (1993–2002) that was played through a chat client integrating chat rooms, email, a buddy list, and a web browser in which players could also receive calls, text messages, and faxes providing clues that helped them to resolve the mystery of the game. In this case, the fiction of the game was seemly interwoven with players' ongoing daily lives. Other games that used similar strategies are *I Love Bees* (2004) and *Perplex City* (2005). Geocaching pervasive games such as *Big Urban Game* (2005) and *PacManhattan* (2004), aiming to disrupt social conventions in public spaces, also belong to this group. A number of early site-specific and interactive works developed by artists such as Myron Krueger, Lynn Hershman, Peter Weibel, Jeffrey Shaw, Monika Fleischman, and Wolfgang Strauss, among others cited in this book, also used varied mechanisms employed in mixed reality performance, as did, in more recent years, Rimini Protokoll's powerful piece *Call Cutta* (2005), a forty-five-minute experience in which participants were guided through an urban environment by call center employees based in India. Far from constituting a contained field, these kinds of works are increasingly affecting other forms of entertainment, such as film and television, social networking, heritage and museums, and even theme parks.

On the Nature of Performance

The second key aspect of mixed reality performance that we need to discuss is performance itself. In its most conventional form, this can mean scripted and staged performances given by actors within the mixed reality environment, and we shall see examples of these later on (although even these often involve actors performing everyday roles such as a receptionist or technician in contrast to more conventional fictional characters). However, there is also a second sense of performance in mixed reality performances in the way in which the traditional audience members of conventional theater are first transformed into being interacting participants or players, and subsequently into being performers in their own right. In large part, this is because

the spread of technologies into everyday settings such as the city streets renders interactions publicly visible and so naturally turns them into accountable acts of public performance—for example, in the way that using a mobile phone on a train or in a café becomes an act of locally staged performance as well as of communication with a remote other. This directly reflects arguments from sociologists such as Erwing Goffman, who accounts for social actions in terms of the "performance" of everyday life (Goffman 1959). Furthermore, some mixed reality performers deliberately implicate passers-by in the experience and thereby potentially transform them into performers, albeit unwitting ones. In short, mixed reality performances establish multiple and coexisting modes of performance often spanning real and virtual environments.

Jane McGonigal, who has written extensively about various aspects of (what we term) mixed reality performance in performance and game studies, has tended to distinguish between ubiquitous computing games "which are deployed to colonise new objects, environments and users in the name of ubiquitous computing," pervasive games, which "aim to critique and disrupt the social conventions of public spaces," and ubiquitous games, which "work to materially replicate the interactive affordances of traditional digital games" (McGonigal 2007b, 233). Crucially, she notes that they have distinctive "reproductive practices" including "the proliferation of gameplay *citations*, the situated proliferation of gameplay *spectacles* and the proliferation of gameplay *affordances*" (233; emphasis in original). She also discusses how ubiquitous computing adopts Donald Norman's user-oriented concept of affordances and cites how Rich Gold, in discussing ubicomp proliferation, foresees that computers will be "embedded and hiding as it were, within the objects of our everyday life." In addition, she points out that "the everyday objects themselves become a kind of ruse" so that, as Gold predicts, "a baby doll (or toy block) might look like a familiar remnant of childhood, but it is really only one of a thousand distributed nodes which control the functioning of the whole house" (1993, 72). These kinds of object-machines then become, for McGonigal, "prompts" (2007b, 235) affording action between digital and physical worlds. McGonigal, who notes that Gold's closing remarks of his essay is "a vision of distributed networks of play and performance" (235), finally suggests that "ubiquitous gaming asks players to take up two core mechanics: first, searching for and experimenting with the hidden affordances of everyday objects and places; and second, exhaustively seeking to activate everything in their immediate environment" (236). These findings are also crucial in our analysis as we show how affordances can be used in design to transform the role of the spectator into a participant and even a performer by a series of trajectories that position the participant on different points of the mixed reality continuum.

McGonigal raises a number of other important points in her research that merit attention at this stage. In discussing her own alternate reality game *I Love Bees* (2004), she introduces the term "power plays," which she describes a being a "cross between

a digital dare and street theater." In defining their characteristics, she depicts them as "live gaming events, conducted in public places and organized via digital network technologies, in which players are directed via clues to show up at a real-world location" (2007a, 252). She then identifies flash mobs as a "quintessential example of a power play" (252). Among its distinctive features, she mentions the fact that participants play in environments in which they usually would not be and interact with others, often strangers, in ways in which they normally wouldn't, but also by making "spontaneous spectacles of themselves" and rewriting the social rules of a given space "in highly visible ways" (252). These games are often guided by what she calls "puppet masters," which she describes as a group of "shadowy, often anonymous figures working behind the scenes as the writers, programmers, directors, and stage managers of the live gameplay" (252). McGonigal reads the relationship between these puppet masters and the power game participants as one of power, though she notes that as the term "puppet master" originated from participants, it denotes their desire to establish this particular type of transaction in this type of artwork. In this book, we shall discuss at length the nature of the "orchestration work" that is undertaken by artists and performers to shape the experiences of participants and players from "behind the scenes" and its impact on traditional performance roles. McGonigal then goes on to discuss how Blast Theory's *Uncle Roy All Around You*'s command-and-control structure raised criticism by Marc Tuters, who in his essay "The Locative Utopia" states that the design of the work has concerned those who feel that it represents "an unwelcome substitution of military logic over the 'real' world" (in McGonigal 2007a, 257). We will show here that although mixed reality performances and other similar experiences are designed in such a way that they do involve a certain degree of steering, they also facilitate emergent creativity and play and stimulate thought about the consequences of performing with "command-and-control" technologies. This is often achieved by means of ambiguity, which we and others (Gaver et al. 2003; Björk 2007, 277–278) identify as distinctive feature of pervasive games. Additionally, we show that here, as in much twentieth-century art, the very role of the spectator is problematic. We know from Söke Dinkla that historically in Futurism, but also in Brecht, and subsequently in American experimental performance and art from the late 1950s and 1960s, the passive role of spectatorship is challenged and audiences are turned into participants, thinkers, and even interactors (2001, 128). But in mixed reality performances, audiences are often encouraged to move from one role to another within the same work, thus gaining multiple perspectives over a given experience.

In summary, though mixed reality performances do indeed involve staging performances in mixed reality environments, the nature of mixed reality and of performance is complex and hybrid, involving multiple spaces, shifting roles, and extended time scales, all of which are connected in multiple ways through diverse forms of interface. Although existing theory from computer science and the humanities contributes to

our understanding of the subtleties of mixed reality performance, they are not in our view sufficient to provide a fully comprehensive account.

Research in the Wild

Our approach in this book is to draw on a series of projects spanning more than a decade, during which the Mixed Reality Laboratory has collaborated with artists to create, tour, and study a series of mixed reality performances. Key to this body of work has been the gradual evolution of a distinctive interdisciplinary approach that tries to combine the goals of artists to create compelling and tourable new experiences with those of researchers who wish to develop new technologies (interfaces or software tools), conduct ethnographic studies of these technologies in use, or ultimately, develop new frameworks to explain them. Our book takes many of these projects as case studies, weaving them throughout its chapters. This involves documenting the experiences, revisiting and extending earlier studies and theories, and also interviewing key figures who were involved at the time. Given its steadily evolving nature and central importance to this book, we now offer a brief historical account of how our underlying research methodology has evolved over the years. Our aim here is to provide some general historical perspective on the case studies that follow and to thereby help place them into an appropriate context. We would say from the outset that our approach has emerged and evolved in quite an organic way and that it still continues to do so.

Although the Mixed Reality Laboratory was formally established in 2000, it grew out of a series of earlier projects and collaborations that had spanned the decade before that, many of them involving what was known as the Communications Research Group or CRG. The focus of the CRG during much of the 1990s was on the technologies and applications of collaborative virtual environments and shared online virtual worlds, but mainly focused support for business productivity in the form of online meeting and visualization tools. During this time, and reflecting a far wider trend in the field of human-computer interaction to incorporate ethnography—specifically, ethnomethodologically informed ethnography—into interactive systems design that had emerged from Xerox PARC in the United States and the Universities of Lancaster and Manchester in the United Kingdom (Hughes et al. 1994; Crabtree 2003), the team began working with ethnographers to conduct naturalistic studies of interaction in and around collaborative virtual environments. Much of this took place within the European COMIC project, a formative Basic Research Action that drew together multiple teams from across Europe who were driving forward the then–rapidly growing field of computer-supported cooperative work. These studies often involved relatively small-scale deployments of prototype technologies among the research teams, taking on the form of iterative quasi experiments in which the results of ethnographic studies

were rapidly fed back into technology design. Early ethnographic studies provided rich descriptions, often through illustrative fragments of interaction transcribed from video recordings, of the nature of embodiment and talk in collaborative virtual environments (Bowers, Pycock, and O'Brien 1996); later ones addressed topics such as jointly manipulating virtual objects, pointing, and the challenge of establishing mutual reference in virtual worlds (Hindmarsh et al. 2000). These studies also informed a series of more theoretical papers that proposed theoretical abstractions for the field such as the "spatial model of interaction" (Benford and Fahlén 1993) that provided a framework of concepts to underpin the negotiation of awareness and communication among the participants of shared virtual worlds.

With the end of the COMIC project came two important reflections that led to a significant change of direction. The first was the recognition that the main applications of collaborative virtual environments would lie in the domain of cultural rather than business applications. Though there would no doubt be applications in engineering, medicine, and other areas, virtual reality is essentially about immersion in a fictional or fantasy world, and the most compelling applications (and surely the largest markets) for this would most likely lie in games, theater, and other forms of social and performative storytelling. The second was the realization that our studies needed to look beyond how the researchers themselves experienced the technologies to instead address the experience of real audiences. In other words, we had to move emerging technologies out of the lab and into public settings as rapidly as possible. Together, these reflections led the team to the realization that it needed to stage and study public events—performances and installations—that built on these technologies, an understanding that was carried forward into two further sibling European projects funded under the European Intelligent Information Interfaces (I-cubed) program, eRENA (more performance-oriented) and eSCAPE (more installation-oriented). Early performances such as the 1996 MASSIVE poetry slam (Benford, Reynard, et al. 2000) and the 1998 Out of this World "inhabited television" show (Greenhalgh et al. 1999) were tremendously exciting technological experiments that certainly produced some strong research papers, but were less compelling as artistic experiences. A response to the challenge of producing work that was both artistically strong yet could sustain innovative research emerged in 1996 through a chance encounter with the artists Blast Theory, who were experimenting with the potential of video projection into water spray as part of a residency at Nottingham Trent University. The synergy between this and the idea of traversable interfaces that was being discussed by the research team was immediately apparent and catalyzed the creation of *Desert Rain* (1998) under the umbrella of the eRENA project, the first project in a longstanding and highly productive collaboration between the Mixed Reality Laboratory and Blast Theory, and one that brings us to the beginning of the timeline for this book.

The approach of collaborating with artists to create and tour new theatrical works which are then subject to ethnographic study was picked up and further developed by the EPSRC-funded Equator project, a major UK research collaboration between eight UK universities into the "interweaving of physical and digital interaction for everyday life" that ran between 2000 and 2007. Coinciding with the official formation of the Mixed Reality Laboratory at Nottingham, Equator was instrumental (along with other funding from the UK's Arts and Humanities Research Council) in delivering *Can You See Me Now?* (2001–), *Uncle Roy All Around You* (2003), *Fairground: Thrill Laboratory* (2006), *Savannah* (2003), and a host of other experiences. Its approach was directly carried on into a further European project, the Integrated Project on Pervasive Games (IPerG) that delivered *Day of the Figurines* (2006) and *Rider Spoke* (2007). IPerG also saw an increasing turn to the humanities to enhance and broaden the basis of the theoretical work from which concepts, frameworks, taxonomies, and other theoretical abstractions would emerge. In particular, the involvement of the Centre of Intermedia at the University of Exeter introduced a new set of perspectives from the performance studies, drama, and new media fields, and brought to bear an extended focus on the documentation of mixed reality performance that has been directly carried forward into this book.

What emerged during this period was a methodology that came to be known as "research in the wild," a term that has since been picked up by the UK's science and technology research council (EPSRC) in its Digital Economy program. This has a few key defining characteristics:

• *Led by artistic practice* Projects would be proposed and developed by professional artists who would have a high degree of artistic control over their content and direction and who would also bring opportunities to stage them in public. Although the broad goals of funded projects and the results of previous projects would clearly provide a framework that would shape or constrain ideas to some extent, the aim was still to facilitate an artist-led exploration of novel applications of technology (when seen from a technologist point of view). This was because artists bring a very great degree of creativity and adventure to research projects alongside opportunities for public deployment and, through this, public communication of research ideas too. The overriding aim was to be adventurous, to take risks, to go public, and to encourage maximum exploration. This was no doubt facilitated by having large-scale, long-term funding, which enabled a degree of self-managed risk taking that is not always possible with shorter, more highly specified grant proposals.

• *Ethnographic studies* Ethnographers would conduct naturalistic studies of public performances, increasingly capturing and analyzing a wider range of documentary material including video, interviews, and system logs. The challenges of working on relatively short timescales and tight turnarounds increasingly involved carrying out

"quick-and-dirty" ethnographies, although it was often then possible to follow these up with multiple studies as a project begun its touring life. The need to handle diverse forms of data also led to the development of new tools such as the Digital Replay System. Key here is that these studies are not hypothesis-led; that is, they are not conventional scientific experiments. They are however informed by sensitizing concepts, which provide lenses through which to attack the challenge of analyzing a novel application. Ethnographic studies are a powerful way of studying practice-led projects, but this approach is not without its tensions—most notably, the need for ethnographers to be able to closely follow, record, and interview participants, which artists may feel will compromise the actual experience itself.

• *Abstracting theory* The final activity involves abstraction of theory such as the trajectories conceptual framework developed in this book. Frameworks, models, taxonomies, and so forth are an essential part of HCI and indeed of computer science in general (the skill of abstraction is perhaps the most important one for computer scientists to develop). Theory is, of course, also an important aspect of scholarly research in the humanities, which also aim to conceptualize broader findings from across a range of specific practice-led examples. Theories typically emerge from long-term reflection across a range of studies. Another important form of abstraction, and one not so directly covered in this book, is that of creating technical platforms and tools. Many of the projects described in this book have been supported by and also contributed to a series of general-purpose software environments, including three generations of the MASSIVE collaborative virtual environment platform and two generations of Equator's Equip platform created by Professor Chris Greenhalgh at the Mixed Reality Laboratory. In several cases, these platforms have been released as open source to the wider community and therefore represent a valuable form of abstraction and generalization of results beyond specific projects.

In general, our research methodology, at least when applied to a specific project, tends to proceed from artist-led creative practice, through naturalistic studies in the wild, to abstractions of theory and platforms. However, there is a danger of oversimplification here, as in the longer term, theories and technologies do feed back into additional projects and/or studies. Thus, although this general trajectory from practice to theory may often hold, there is in the detail a more complex set of relationships at play, as summarized (in a highly simplified way) by figure 0.2. Here we see that practice provides data for studies, but also that these can feed back directly into practice through iterative design. We see that multiple studies ground emerging theory, but also that theory provides sensitizing concepts for studies. Finally, we see that theory can lead to concrete design guidelines and design patterns that inform future practice, while it is also possible to derive some theoretical insights directly from documentation and critical analyses of practice.

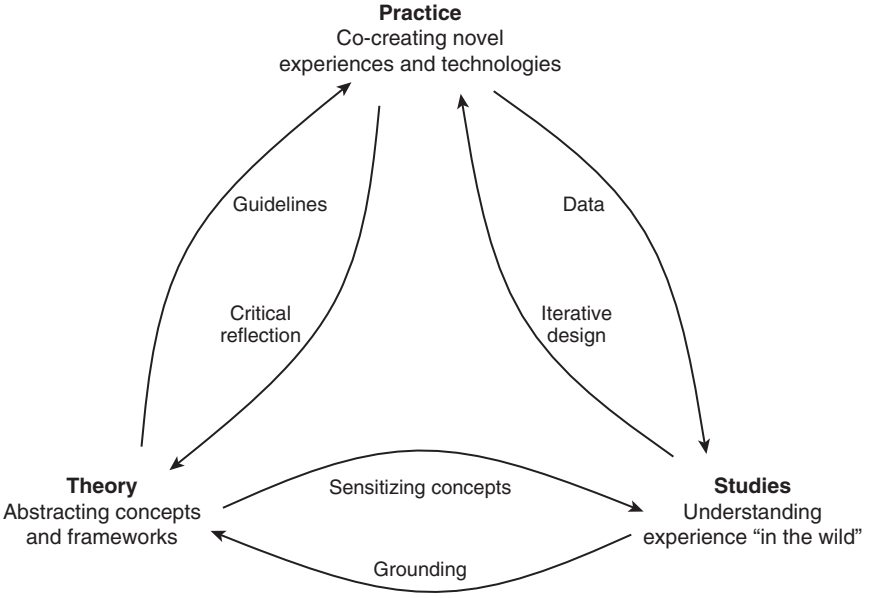

Figure 0.2
Relating practice, studies, and theory.
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Of course, our approach continues to evolve from project to project, so this diagram is not only a simplification of what actually takes place, but also merely gives a snapshot of where we are at the time of writing this book. How might we expect the approach to further evolve over the coming years? One of the most exciting recent developments has been the launch of the RCUK-funded Horizon Centre for Digital Economy Research at Nottingham. This provides a further long-term opportunity to support new projects over the coming years, with a particular focus on how ubiquitous computing can enhance the creative industries. Moreover, this new project actively seeks to widen the net and draw from the disciplines of business and management studies, film and television studies, sociology and psychology, performance studies, and new media to further broaden our perspective on how we understand emerging forms of interactive experience such as mixed reality performance.

A Theory Based on Trajectories

This book documents landmark examples of mixed reality performance and develops a new theory illustrating how they work. By "theory," in this context, we mean a framework of concepts that can serve to explain how existing mixed reality perfor-

mances are designed, account for how they are experienced, articulate design strategies for creating future experiences, and relate developments in this new field to other fields and existing bodies of knowledge. To do this, we recur to an interdisciplinary body of work. Within the humanities we draw principally on new media theory, performance studies, and game studies, although we also use anthropology, design, and geography. Within social science we draw on ethnographic studies, and within computer science we draw on HCI, CSCW, ubiquitous computing, and virtual and mixed reality. Interestingly, two of our principal disciplinary perspectives in this book, human-computer interaction and performance studies, both came to prominence in the late 1960s/early 1970s. HCI emerged from human factors engineering and, since the 1990s, has also encompassed design, leading to the practice-based approach of interaction design. Performance studies, on the other hand, originated from theater studies in the late 1960s. For Richard Schechner, who initiated the discipline at that time, it includes the studies of "gatherings of every kind," but also "the structure of sports, ritual, play, and public political behaviors" (1973a, 3). Thus both HCI and performance studies are inherently interdisciplinary, and both are concerned with processes and practices that are experienced and performed in everyday life. Between them, they provide ideal and complementary departure points for the challenge of developing a theory of mixed reality performance.

We have already seen earlier when defining the term "mixed reality performance" that existing disciplines already have a great deal to say about the subject from their various perspectives. Indeed, there is a wealth of existing theory that might underpin any new theoretical approach. Computer science provides a number of theories and paradigms that are relevant here. Though the desktop PC remains the dominant form of computer interface today, this is rapidly changing, and the discipline has already yielded several competing visions of how to move "beyond the desktop." The paradigm of virtual reality and associated theories of presence concentrate on stepping "through the screen" to become immersed in a computer-generated virtual world, best seen in the spread of interactive computer games. Ubiquitous computing, which was originally framed as the antithesis of virtual reality, considers the explosion of computing from out of the desktop into the everyday world around us, broadly encompassing a variety of other ideas such as mobile, wearable, tangible, pervasive, embedded, and ambient computing. Mixed reality performances tend to combine both of these approaches. They are more akin to Milgram and Kishino's definition of mixed reality, which, as we have discussed earlier, considers a continuum as a way of capturing this relationship between immersion and ubiquity.

At the same time, mixed reality performance also exhibits distinctive temporal, spatial, and perfomative structures that are not addressed by the previously mentioned theories of mixed reality, but can be addressed through perspectives offered by performance studies, theater studies, and drama. Previous studies have discussed the

theatricality of computer interfaces and stressed that because of it interface design has become "an *interdisciplinary* concern" (e.g., Laurel 1993, 5; emphasis in original). Other studies used theater and performance studies to describe pervasive gaming experiences (e.g., McGonigal 2006) and addressed the implicit theatricality and performativity of interactive experiences (Dinkla 1997, 2001; Giannachi 2004). Likewise, well-known game studies have utilized conventional dramaturgical concepts like space, time, characterization, and role-play (Wardrip-Fruin and Harrigan 2004; Salen and Zimmerman 2004) to explain how games operate. Most crucially, relevant studies in new media—such as Martin Rieser and Andrea Zapp's *New Screen Media/Cinema/Art/Narrative* (2002), Steve Dixon's *Digital Performance* (2007), Matthew Fuller's *Media Ecologies* (2005), or Susan Kozel's *Closer* (2008)—have investigated aspects of the field theoretically, often drawing from a number of disciplines. Although mixed reality is specifically mentioned in a number of these studies, only a few refer to it more extensively, such as Mark Hansen's influential *Bodies in Code* (2006), arguing that embodiment is now indissociable from technology, or, less explicitly, Lev Manovich's *The Language of New Media* (2001), which however formulates the necessity for the "emergence of a new cultural metalanguage" (93) able to define a culture that is increasingly "encoded in digital form" (70).

In other words, there is no shortage of existing theory that might help explain the nature of mixed reality performance. Yet we do not find existing paradigms sufficient to capture what, from our experience, is the essence of this new theatrical form. We shall argue throughout this book that mixed reality performances are neither virtual reality not ubiquitous, tangible, ambient, or embedded computing, or any single point on the virtuality continuum, but rather involve combinations and juxtapositions of all of these to create complex hybrid structures. In turn, they are also not simply traditional performances, conventional computer games, or even new forms of pervasive or alternate reality games, but rather mix all of these performance aspects into yet more hybrid structures that span diverse performance roles, time, and technologies. Our core argument is therefore that a new theoretical approach is required to capture both the essence and detail of mixed reality performance, and for this we turn to the idea of *trajectories*.

Why Trajectories?

Our analysis of mixed reality performance is based on the underlying idea that these forms of events are constituted by a number of embedded and emergent trajectories through an experience. We consider an experience to be a complex mixture of space, time, interfaces, and performance roles that are connected into a sophisticated structure using computing technologies. A participant's experience is constituted by a

journey through this structure. Each participant may follow his or her own routes or trajectories, which intertwine and interweave in different ways to create social structures. Trajectories emphasize aspects of journey, continuity (with key transitions), future and past, perspectival points of view, and weaving and crossing, and thereby offer a distinctive starting point for considering mixed reality experiences. Moreover, trajectories can embody future planned action as well as past action, and thereby express not only a spatial and social, but also a temporal continuity of experience spanning past, present, and possible futures. Unlike routes or journeys, trajectories embrace both embedded and emergent narratives, thus representing not only a direction or path, but also a way of experiencing and performing mixed reality environments.

Etymologically speaking, a trajectory differs from a line, journey, thread, or trace in that it implicates the act of throwing across (*trans jacere*) and therefore indicates the movement of a body or object through space and in time. *Trans*, of course, alludes to the act of going beyond or across, of traversing and therefore also encompassing different worlds. But trajectories do not merely indicate a mode of transport. Whereas transport, as anthropologist Tim Ingold suggests, is "destination oriented" (2007, 77), trajectories express the progressive itinerary of a body or object as originated by an agent. This implies that both the agent, whether human or other, and the body or object itself can determine the precise direction and duration of a trajectory. In other words, a trajectory is influenced by an agent and by context. One can predict a trajectory, even mathematically, but never be in absolute control of it, as it is impossible to fully manage the context that determines how it is practiced and experienced at every given point in time. It is also impossible to define in absolute terms how a trajectory is likely to evolve over time. The object of a trajectory is therefore in a persistent state of unrest.

In this book, we use the term "trajectories" to indicate predicted and actual itineraries through mixed reality experiences. These emerge as the result of diverse types of navigation, journeying, and mapping. To describe the differences between these types of movement and understand what they might mean within the context of mixed reality performance, we recur to Ingold and start by saying that as knowledge about an environment is determined while we are "on the move" within it (2000, 230), and the environment is "perceived not from multiple points of view but along a path of observation" (238), the primary means by which to experience a mixed reality performance environment consists of the trajectories or paths of observation and experience that facilitate one's route through it. It is important to remember that these are both embedded and emergent and in some way represent the development of perspective within an art form, mixed reality performance, that is formed by the juxtaposition of digital and physical environments.

Trajectories throughout the History of Art

Most art forms have engaged with concepts that are related to our definition of trajectories. We now briefly introduce some examples to explore the similarities and differences between our definition of trajectories and uses of similar concepts in other disciplines and across different historical moments.

Trajectories in Theater Theater, performance, and new media all involve the creation of paths of observation. These are frequently related to paths of actions carried out by the actors or performers, with respect to the context dictated by the plot, its setting, and interactions with other performers both on and off stage. In the theater, the audience tend to experience paths of observation and of action collectively from the auditorium, whereas in experimental performance, where the audience is often dispersed and sometimes even on the move, possibly for prolonged periods of time, they are usually experienced subjectively. An example from theater is offered by Constantin Stanislavski's use of lines in *An Actor Prepares*, in which the naturalist director distinguishes between short, long, and broken lines, all to remain, however, "on our side of the footlights, and not to stray once into the auditorium" (1980, 258). Another example, this time from an experimental theater director, is constituted by Richard Foreman's use of strings on stage, which, in Foreman's words, intended to signal "that amorphous aspect of true-to-life perception, interfering with objects and actors, but also superimposing what I imagined to be 'lines of force' echoing the many trails of energy that do shoot through our lived visual field" (1992, 61). Interestingly, in both cases lines were used to indicate paths of observation that directly positioned the audience outside of the environment represented on stage, whereas in mixed reality performance the audience is usually located within both the physical and digital environment.

Trajectories in Performance Art In performance art, lines have been used to indicate the audience's route through a site, as is the case of Lynn Hershman's early site-specific work *Re:Forming Familiar Environments* (1975). In this work, Hershman hired members of the group COYOTE to perform tableaux in various rooms in Eleanor Coppola's house "doing simple everyday tasks such a taking a bath, sleeping, or peeling potatoes" (Tromble 2005, 44). Hershman in fact claims to have used trajectories to convert "ordinary and often overlooked spaces into extraordinary sites for expanded awareness." Thus, she says, "floor plans of the house were designed into game boards" and because the game's objective was "to (as minimally a possible) transform an inhabited dwelling; to alter perceptions about the potential uses of familiar environments" (Hershman 1975), trajectories were adopted to map the locations in which this contamination between the everyday familiar environment and its uncanny transformation into art occurred. Subsequently, Hershman used this term to define the relationship

between networked identities, in an article about her synthetic female agents, *The Dollie Clones* (1995–1998), *Synthia* (2000–2004), *Agent Ruby* (1991–2004), and *DiNA* (2004). So, she notes, these "expand the possibility of singular identities into a networked trajectory composed of flowing data that eats itself, cannibalizing in the process information that mutates and is re-expressed in unpredictable ways" (2005, 209). Finally, Hershman used this term again in an interview (Giannachi 2010) in which she was discussing her interactive work *Lorna* (1982). Here she described them as a way of "trying to understand a direction that something's going, imagining how it's going to go, the staging of a process in the future." Though from an authorial point of view trajectories marked an imagined future path, from a given participant's point of view they constituted both the audience's path of observation and their path of experience. Crucially, as in the case of Foreman's work, they were used here to play with, but also to alter perception with respect to the relationship between the artwork and everyday life. In this sense, trajectories are not just scenarios, but rather hypotheses of movement and behavior that create a rhizomatic three-dimensional structure within which participants journey for prolonged periods of time.

Trajectories in Architectural Works Although trajectories are useful in determining an audience's path through an experience, they also constitute an important means to enmesh a work within a broader matrix of intertextual references. Architectural works often use lines in this way, such as—perhaps most famously in recent times—Daniel Libeskind's Jewish Museum in Berlin, the design of which was based, in the architect's own words, "on the invisible figures whose traces constitute the geometry of the building" (1999, 17). Thus the Jewish Museum follows the contours of an invisible broken Star of David, designing intertextual trajectories that intend to connect individual addresses in the city. The building itself is located at the intersection of Markgrafenstrasse and Lindenstrasse at the edge of Friedrichstadt, the district named after the first King of Prussia, Friedrich I. During the war, the entire area (part of which belonged to former Eastern Germany) was raided and almost completely destroyed except for two major buildings: the baroque Collegienhouse built by Philipp Gerlach in 1735, in which the writer E.T.A. Hoffmann served as a judge, and the German Metalworkers' Union Building, a major piece of European Modernism built by Erich Mendelsohn (1930). Markgrafenstrasse connects the museum with the square Gendarmenmarkt hosting the Karl Friedrich Schinkel Schauspielhaus (1821), as well as the German and French cathedrals built by Karl Gontard in the eighteenth century. The other street, Lindenstrasse, connects the site with the Berlin City Hall and what is left of the Old Town. The intertextual tension created by this matrix of addresses produces lines through which the building may be navigated and which embrace structural voids left by the building's architecture that symbolize the void left by the Holocaust. Creating connections between the warm curved lines of the baroque and the colder

straight lines of modernist architecture, the museum spreads its wings across hundreds of years of history, stretching itself, like Benjamin's famous Angelus Novus (Benjamin [1955] 1992, 249), toward the future, while staring into the pile of debris left by Germany's past. Libeskind's work is an important example of how trajectories can span physical and cultural environments, a distinctive feature of a number of the mixed reality performances analyzed in this book.

Trajectories in Painting and Film In painting and subsequently in film, writings on the importance of lines—particularly in relation to Renaissance perspective but also at the time of the avant garde—abound, with the painter Wassily Kandinsky, for instance, drawing attention to the fact that lines are the "anti-thesis" to points because they entail an application of one or more forces, hence implying movement, but also tension and direction ([1947] 1979, 57–112). Similarly to Foreman's "lines of force," Kandinsky's use of the term thus reminds us that trajectories imply forms of "gravitational pull," or steering, and that they are useful not only to structure and analyze experiences, but also to study how these evolve over time. Another art form that influenced our definition of trajectories in mixed reality performance is film. Among a number of directors who wrote about lines in film is Sergei Eisenstein. Influenced by the use of lines in Renaissance painting, Eisenstein describes how lines can be utilized as a way to visualize "the character of a movement." So he notes that the construction of "concrete picturizations of roads along which were distributed the events that the artist wished to portray in particular sequence," typical of early graphic art ([1943] 1968, 148–150), was used to define complex spatiotemporal coordinates. As an example, he cites Domenico Ghirlandaio's *The Adoration of the Shepherds* (1485), showing that "the infant surrounded by the shepherds occupied the foreground, and on that twists forward from the background appear the Magi; so that the road ties together events which are, in subject, thirteen days apart" (150), indicating the development of a timeline or narrative trajectory within the painting's spatial setting. In a subsequent period, Eisenstein points out, the road is replaced by a "path of the eye," marking the change from a sphere of "representation to one of composition" that, once perspective started to be used, often included the viewer into the journey. So, he notes, "there is usually something in a painting which attracts attention before all other elements. From this point the attention moves along that path desired by the artist" (150). In mixed reality performance, the hybrid environment is designed or, to utilize Eisenstein's terminology, composed, in the sense that physical and digital aspects are considered as if in dialog with one another. Just as in film, dolly zooms are able to traverse environments and create trajectories across space, in mixed reality environments paths are designed along which real and virtual environments may be viewed and/or experienced in their relationship to each other and details from one made to have an impact on the other. In film, as Eisenstein notes, frames are able to

"gauge the movement of the eye over a determined path" (151), which can then be matched to paths created by other forms like music or narrative (139); in mixed reality performance, cultural, physical, and digital data can be juxtaposed or intertwined to generate a complex hybrid compositions of fictional, physical, and virtual worlds.

Trajectories, Mapping, and Wayfaring

Although spatial navigation and the consequent design of routes, journeys, and even trajectories straddling across sites is not a novel practice in art, the span of these in mixed reality performance across real and virtual environments constitutes a crucial difference in the way trajectories are designed and practiced. The mixed reality performances we discuss in this book are locative, with some, as in the cases of Hershman and Libeskind, being also site-specific or site-sympathetic. Participants to these experiences tend to behave like Ingold's traveler who, in mapping, "knows as he goes" (2000, 231). This idea that to perform the mixed reality space the participant must map it is crucial in our analysis. To explain the implications of this assumption, we shall refer to Ingold, who describes how through cognitive maps the traveler does not plot their routes mechanically from A to B, as if executing a prescribed course, but rather "'feels his way' toward his goal, continuously adjusting his movements in response to an ongoing perceptual monitoring of his surroundings" (230). Proceeding by feeling their way is the principal means by which participants in a mixed reality performance perceive the hybrid environment in which they are located, and because this strands between real and virtual, this operation has to occur in both the physical and the digital worlds. This means that though participants to mixed reality performances may use maps, or even make maps as part of their experience, they are also mapping, in the sense that they are feeling their way through an unknown environment precisely in order to know it, constantly renegotiating the real and virtual elements that form it, learning to move *between* them, affording one *through* the other.

In this book, we show that artists design mixed reality performances through a variety of mapping strategies and that subsequently participants to a mixed reality work tend adopt a number of mapping and navigational practices to explore the environment, including wayfaring, trail-finding, and preplanned navigation. To explain the absolute difference between the forms of movement that mark the use of these trajectories, we shall refer again to Ingold. For him, though the navigator plots a journey through a cartographic map and then explicates the plot, in wayfaring "one follows a path that one has previously traveled in the company of others or in their footsteps, reconstructing the itinerary as one goes along" (2007, 15–16). Whereas all wayfaring is mapping, navigation, Ingold notes, is map-using (2000, 231). So travelers in antiquity and the Middle Ages were wayfarers rather than navigators, in that "they did not interpret the writing on the page as the specification of a plot, already composed and complete in itself, but rather saw it as comprising a set of signposts,

direction makers or stepping stones that enabled them to find their way about within the landscape of memory" (2007, 235). Participants in mixed reality performance works are required to use both wayfaring and navigational skills. They map in that they reconstruct, often collaboratively, predesigned journeys by using physical and digital signposts not only to orient themselves in a given mixed reality environment, but also to design it at the same time. Moreover, they navigate by plotting their own journey in space via predesigned maps and occasionally design their own maps to further aid the navigational process or create mementos of their experience.

Trajectories in Past and Future

In order to conclude this initial discussion of trajectories, we need to dedicate some attention to the role played by traces, or practiced, historical trajectories. The trajectories that artists inscribe into mixed reality performances as well as those that participants actually follow also leave behind traces that affect future experiences. Of course, the processes and interactions engaged with in the making of and encounter with most art forms generate traces. These often act as documentation, and occasionally also operate as canonical examples of spectatorship, engagement, or participation. In much conceptual art, these traces become the work itself, whether in their own right, as in Giuseppe Penone's *Alpi Marittime* (*Maritime Alps*, 1968), in which the artwork consisted of the documentation of Penone's aesthetic interventions in a forest, or in their relationship with the "original," as in Robert Smithson's *Mono Lake Nonsite* (1968), which was composed of both the site representing the location from which materials had been taken and the nonsite located in the gallery. But in practicing mixed reality performance spaces, participants not only produce traces in physical locations, but also generate what we call "contextual footprints," digital records of their passage through both virtual and physical worlds, the latter increasingly captured through a variety of sensing systems such as the Global Positioning System (GPS), wearable biosensors and others. Some of these footprints are accidental, in that they were generated through technologies belonging to third parties that unintentionally captured the event (such as CCTV); some are external, in that they are generated via interactions occurring through social networking that do not in themselves form part of the artwork but that could be used to understand the broader context in which a work is generated, advertised, and received (such as artist- or user-generated images, sound files, and videos placed on Flickr, Facebook, MySpace, YouTube, or Twitter updates); others are intrinsic to the technologies used to produce the experience itself (such as GPS). Within the latter category, some footprints may form part of the work itself and become visible by participants; others may remain invisible to participants but could be used at a later point in time for evaluation and analysis. For instance, environmental footprints are likely to become increasingly important, and artists are already working with emotion footprints indicating how people respond to stimuli in

a given cartographical and social context (e.g., Christian Nold's emotion mapping) and thrill footprints generated by utilizing adaptive rides aimed at the generation of thrill in entertainment parks (e.g., Brendan Walker's work presented in chapter 4). Within the context of mixed reality performance discussed in this book, some of the contextual footprints operate primarily as a documentation of the work, as in the case of the positional readings in *Can You See Me Now?* or *Uncle Roy All Around You*. Others, however, become part of the work itself, like the recordings left by riders in *Rider Spoke*, generating traces and trails leading participants onto particular journeys through the work. The concept of trajectories then becomes a useful tool to explore the value of these contextual footprints, which encompass data produced by artists, technologists, participants, and even bystanders, as well as users engaging with the work at a much later point in time, thus constituting the basis of a "*live* archive" that is able to evolve and reflect about itself over time.

However, contextual footprints have value not only because they tell us about past and emergent behavior, but because, like traces or trajectories, they may inform future behavior. Anthropologists tell us that traces play a fundamental role in the way that memories are transmitted from one generation to another. The wayfarer, Ingold notes, "lays down a trail in the ground in the form of footprints, paths and tracks" (2007, 79). Thus, he argues, "one learns by discovery while following in the *path* of an ancestor" (2000, 146; emphasis in original). Trails, therefore, are not just routes to remembrance, but are "routes to knowledge" (Lye in Ingold 2000, 148). In this sense, the past becomes the key that unlocks our future. This suggests not only that we learn through mapping but also that we learn future directions by mapping existing trails. Trajectories mapping traces of digital footprints can therefore play a crucial role not only in the way we study and learn from mixed reality performance, but also in the way in which we are likely to develop future knowledge and behaviors. Just as paths "impose a habitual pattern on the movement of people" (Jackson 1989, 146), such trajectories, and the contextual footprints that form them, may influence the "habitual pattern on the movement" of others.

For Ingold, "mastery consists in knowing what the environment looks like from all practically available *paths* of view, that what the traveler remembers are vistas and transitions" (2000, 239; emphasis in original), or a "passage from one vista to another" (238) rather than location-specific images, and that keeping track is a matter of regenerating the flow of perspective structure over time" (239). Within the context of a mixed reality experience, "mastery" then becomes practiced knowledge of canonical and participant, but also, crucially, historic trajectories that allow for the possibility of replaying and thus regenerating the perspectival view of the intersection between trajectories over time. Roy Wagner, writing about the aboriginal people of the Australian Central Desert, takes the impact of routes further, saying that for some cultures "the life of a person is the sum of his tasks, the total inscription of his movements,

something that can be traced out along the ground" (1986, 210). Much locative work discussed in this book adopts hunter-gatherer habits, such as direct procurement, through missions, of means of survival from the "wild," so participants are required to remain "at one" with their environment—a distinctive feature of hunter-gatherer societies being that they do not approach their environment as "as an external world of nature" (Ingold 2000, 42), except that here the environment is both digital and physical, so the expression "at one" has to be adjusted to encompass both and to take into account the contamination of one through the other. Trajectories thus become the lines necessary for participants to orient themselves in this hybrid mixed reality environment generated by the juxtaposition between digital and physical worlds. The contextual footprints generated by such experiences then become the inscriptions through which our movements in space and time are marked. Through them, we can look at ourselves from another perspectival viewpoint, and analyze the very fragments and traces of our presence that may one day be adopted by an other to see what we saw and be who we were from within the world we temporarily inhabited.

To conclude, we are increasingly affected by the way that ubiquitous computing experiences, including mixed reality performances and other forms of elite and popular entertainment, are integrated in our daily lives. Trajectories, as we have seen, are useful not only for the design of these kinds of environment, but also for the design, management, and understanding of other aspects of past, present, and future living that are becoming increasingly part of a mixed reality. As Dourish noted (2001), trajectories could be used as a means to understand how social worlds may develop as a way to reflect about how to use trajectories to design a better future. For this, we recur to Gilles Deleuze and Felix Guattari's writings on lines in *A Thousand Plateaus* (1988). Here, the philosophers note that we do not just journey on lines but are rather traversed by them (meridians, geodesics, tropics, and so on) and are composed of bundles of multiple lines that are in part imposed on us from the outside and in part the result of our own making. To support their argument, they cite Fernand Deligny's study of autistic children in which "he transcribes the lines and paths of autistic children by means of *maps*: he carefully distinguishes 'lines of drift' and 'customary lines'" and, as well as walking, generates maps of perception and gestures and even language (in Deleuze and Guattari 1988, 202, and Deligny 1975). They write, "The lines are constantly crossing, intersecting for a moment, following one another. A line of drift intersects a customary line, and at that point the child does something not quite belonging to either one" (203). In this rhizomatic economy of lines, they note, "we must invent our lines of flight" (202). It is crucial that trajectories that are about designing but also about understanding the relationship between systems and individuals should allow for lines of flight, marking the possibility for evasion, difference, and change. Here, far from proposing merely a model of control, we explore how—through trajectories—paths can be designed that, by subverting the way we look and

experience things, and by repositioning us within the *polis* of everyday life, have a powerful aesthetic, social, and even political impact.

The Structure of the Argument

Performing Mixed Reality has begun with an introduction to the definition of mixed reality, undertaking an initial investigation of what the term, and the practice it defines, have come to mean within HCI, new media, and performance studies, and especially to the work of the Mixed Reality Laboratory over the last decade. Following an analysis of why this field is best presented through an interdisciplinary approach, encompassing HCI, performance studies, new media, and game studies, as well as aspects of anthropology, geography, and ethnomethodology, the introduction has moved on to motivate and present the core concept of trajectories as a theoretical foundation for studying and realizing mixed reality performances. The following chapters now investigate in more detail the role played by trajectories in four key aspects of mixed reality performances—space, time, interaction, and performance—with each presenting key artistic events, educational games, or forms of popular entertainment that variously utilized mixed reality. At a theoretical level, the chapters draw principally from HCI, performance studies, and new media theory, though most analyses are also indebted to a number of ethnographic investigations conducted by Mixed Reality Laboratory staff over a period of eleven years as part of a series of EPSRC- and EU-funded projects. All chapters present original interviews with key figures in the field, including artists Matt Adams and Nick Tandavanitj from Blast Theory; United Kingdom–based thrill engineer and artist Brendan Walker, who has been collaborating with the Mixed Reality Laboratory since 2006; and staff from the Mixed Reality Laboratory itself, including architect Holger Schnädelbach, ethnomethodologist Andy Crabtree, and HCI researchers Boriana Koleva and Martin Flintham, who variously contributed, alongside the artists, and other staff from the lab who are cited throughout this book, to the development of the technologies, theories, and practices described in this monograph.

Chapter 1—on space—shows how mixed reality performances generate hybrid realities that span physical environments and virtual worlds. These hybrid spaces tend to encompass events that occur on different points of the mixed reality continuum, and are often juxtaposed or adjacent rather than superimposed upon one another. The seeming dichotomy between the physical and the virtual turns these hybrid environments into spaces of disjuncture, in which participants are made to feel "off balance." The chapter shows how hybrid spaces can be designed but also navigated through a combination of embedded or emergent trajectories. Focusing on Blast Theory's locative works *Can You See Me Now?* (2001–) and *Uncle Roy All Around You* (2003), as well as introducing the educational game *Savannah* (2003), this chapter analyses the salient

features of these kinds of spaces, shows how they are designed through a number of interweaving canonical and participant trajectories, and notes that they are often constructed communally, as the result of a network of collaborations spanning between physical and digital worlds, and intertextually, linking the performance environment to matrixes of cultural, geographical, and historical addresses. Finally, the chapter explores how the nature of the ubiquitous computing infrastructure of wireless positioning and communication technologies that underpins hybrid spaces shapes the mixed reality performances that occur within them so that the site of performance may constantly shift during a given event due to changing coverage or accuracy of the technology used. We show how the "seams" in this infrastructure—that is, gaps in coverage and limited accuracy—have an impact on different participants' experiences, and discuss how trajectories are designed to cross such seams.

Chapter 2—on time—turns its attention to the idea of a hybrid, layered time within mixed reality performance, exploring various mappings between story time and clock time. The chapter, which adopts Blast Theory's pervasive game *Day of the Figurines* (2006) as a case study, also reflects on findings in sociology and philosophy of media claiming that we are witnessing the introduction of new forms of temporal organization that allow for fluidity between previously separate fields of social existence, such as work and entertainment. The chapter then introduces a general framework for describing the hybrid temporal structure of mixed reality performance in terms of five distinct layers of time—story time, plot time, schedule time, interaction time, and perceived time—and proposes the concept of temporal trajectories to express different mappings between them. Finally, the chapter presents an analysis of the value and nature of recording and replaying mixed reality performances.

Chapter 3—on interaction—focuses on the design of computer interfaces supporting mixed reality environments that are spatially and temporally hybrid. These interfaces are often tangible, embedding digital information and computation into physical artifacts, and sometimes traversable, establishing the illusion that virtual and physical worlds were adjacent, or joined together in such a way that one could move from one to the other. Focusing on Blast Theory's *Day of the Figurines* (2006), their early performance work *Desert Rain* (1998) and the museum installation *Flypad* (2008), as well as the site-specific *Shape Living Exhibition* (2001) designed by Mixed Reality Laboratory staff, the chapter explores the "transformative" role played by interactional trajectories in connecting these hybrid ecologies of interfaces. The word "transformative" is used to indicate how they facilitate the transitions that turn passive spectators into active participants or even performers, and herewith prompt or afford the action that is at the heart of the interactive process. Finally, the chapter discusses a taxonomy of spectator interfaces based on four strategies of designing secretive, expressive, magical, and suspenseful interfaces.

Chapter 4—on performance—considers the nature of participation in mixed reality performance by exploring trajectories through different performance roles. The chapter starts by analyzing the construction of theatrical, performative, and participatory roles in mixed reality performance, focusing on a triangle of core roles: performers, spectators, and orchestrators. It then discusses how participants move between these roles in a number of case studies, such as Brendan Walker's *Fairground: Thrill Laboratory* (2006) and Blast Theory's locative works *Rider Spoke* (2007) and *Ulrike and Eamon Compliant* (2009). Focusing on the function of framing, ritualization, and transactions, the chapter discusses how participants are given license to perform, thus constantly readjusting their position between everyday life performance in the physical world and performance in the digital world, resulting in the two contaminating one another. The chapter also analyses the changing nature of participation, and suggests that mixed reality performances involve a complex ecology of hybrid roles. Following a detailed analysis of the increasingly important role of orchestration, the chapter concludes with a discussion of how transitions, transactions, and journeys through these roles can be explained in terms of trajectories.

Finally, chapter 5—on trajectories—brings these discussions together by drawing out the general properties of trajectories, defining a framework of concepts that can guide researchers and artists who work in this field. The framework introduces three fundamental forms of trajectory: canonical, participant, and historic; identifies key transitional moments that may occur along these trajectories; and discusses how the interweaving of trajectories can express the social and collaborative aspects of an experience. These concepts are then put to work to analyze and explore alternative designs for two of the works introduced in previous chapters: *Uncle Roy All Around You* and *Day of the Figurines*. The framework aims to provide sensitizing concepts to guide future empirical studies; compile artistic craft knowledge into a form that is useful to a wider range of designers; identify requirements for new technologies; and ultimately establish the foundations for a dramaturgy of interactive user experiences. To conclude, the chapter draws attention to the actual and possible uses of trajectories in other subject areas.