From Interaction to Trajectories: Designing Coherent Journeys Through User Experiences

Steve Benford, Boriana Koleva, Tom Rodden
Mixed Reality Laboratory
University of Nottingham
Nottingham, UK, NG81BB
sdb@cs.nott.ac.uk

Gabriella Giannachi
Centre for Intermedia, Department of Drama
University of Exeter
Exeter, EX44LA, UK
G.Giannachi@exeter.ac.uk

ABSTRACT

The idea of interactional trajectories through interfaces has emerged as a sensitizing concept from recent studies of tangible interfaces and interaction in museums and galleries. We put this concept to work as a lens to reflect on published studies of complex user experiences that extend over space and time and involve multiple roles and interfaces. We develop a conceptual framework in which trajectories explain these user experiences as journeys through hybrid structures, punctuated by transitions, and in which interactivity and collaboration are orchestrated. Our framework is intended to sensitize future studies, help distill craft knowledge into design guidelines and patterns, identify technology requirements, and provide a boundary object to connect HCI with performance studies.

Author Keywords

User experience, trajectory, cultural applications, games, performance, museums, space, time, role, collaboration

ACM Classification Keywords

H.5.3 [Information Systems] Group and Organization Interfaces – *Collaborative Computing*.

INTRODUCTION

Over recent years, HCI has extended its focus to consider what might be termed "cultural applications" of computing and the new challenges posed by an emerging generation of artistic, entertainment, leisure, heritage and social experiences. The term "experiences" is carefully chosen here to reflect a further shift in focus beyond considering conventional usability to also consider concerns such as affect, sensation, pleasure, aesthetics and fun, and their contribution to the idea of there being an overall *user experience* [11, 21].

Diverse examples have shown how computers can be embedded into wider cultural experiences. Interactive tours and museum installations have integrated digital media with physical artifacts and places [1, 2, 8, 28, 31], while mobile games [10], enhanced live action role play [18], and pervasive artistic performances [3, 4] have combined digital media with physical locations, props and live action. Other experiences have shown how wearable and public displays can enhance amusement rides [24]. These examples illustrate key challenges for designing engaging user experiences that draw together multiple technologies, interfaces, physical artifacts and people into complex structures that extend across space and time. How should HCI engage with these new forms of user experience? What concepts and frameworks are needed to understand and ultimately to design them?

This paper develops the concept of *trajectories* through user experiences as one which has relevance and purchase for HCI in understanding and designing for broader cultural applications. Various notions of trajectory have already emerged from several recent HCI studies. Ethnographic studies of interactive installations in museums and galleries have revealed how visitors attend to the conduct of others and how this may shape their trajectory towards an installation [29]. Researchers studying tangible interfaces have argued that the physical design of tangibles must be carefully related to their surrounding environment so as to similarly establish a trajectory of interaction [15]. A study of a touring artwork in which users controlled kaleidoscopic images through physical movements discussed how "common elements, which could be seen to occur in a similar order in each individual encounter" formed an overall "trajectory of interaction" [12]. In a different vein, reflections on a slowly unfolding text messaging game for mobile phones introduced "temporal trajectories" that express mappings between story time and clock time in interactive narrative and helped reason about issues such as episodic engagement and synchronization [5].

It appears then that the idea of there being *trajectories of interaction* is gaining some currency within HCI. In this paper, we refine and develop this idea further. By revisiting and reflecting on several previous studies we demonstrate the relevance of trajectories to understanding how complex

user experiences are designed and experienced. This enables us to refine the basic idea of trajectories, extending it with greater detail and related concepts to ultimately arrive at a conceptual framework for understanding cultural user experiences. The framework elaborated in this paper is intended to speak to audiences within and outside of HCI:

• It offers empirical researchers 'sensitizing concepts' [6] to guide their approach to studying user experiences and provide a starting point for interpretation.

• It provides practitioners with a framework for compiling and analyzing the extensive craft knowledge that already exists among artists and other experience designers.

• It helps technology researchers and developers identify requirements for new tools and platforms to support the development and orchestration of future user experiences.

• It acts as a boundary object [25] between the disciplines of HCI and performance studies, laying the foundations for a dramaturgy of interactive user experiences.

We will expand on these uses of our framework at the end of this paper. However, we begin by briefly reviewing four key user experiences that have motivated our approach to trajectories and that provide the core material for our reflections in this paper. Between them, they embody and combine a variety of spatial and temporal structures, roles and interfaces, and each has previously been studied and documented in the HCI literature. As background, we offer a brief overview of each and summarise the key findings from previous studies.

DESERT RAIN

The interactive experience *Desert Rain* toured to more than ten cities worldwide between 1999 and 2006. Desert Rain explored the theme of the first Gulf War. Six players at a time were sent on a collective mission into a virtual world to locate six 'targets', individuals with contrasting perspectives on the war, including soldiers, peace-workers, journalists and people who watched television coverage. The structure of Desert Rain deliberately reflected various representations of warfare in different media, combining elements of computer games, video recorded interviews, and live performance, and embedding all of these into an extensive physical set that included a briefing room, a reconstruction of a motel room, six fabric cubicles and a connecting corridor.

Having purchased tickets, each group of participants was admitted into their own forty-five minute performance. This commenced in a bare antechamber with a military-style briefing, during which their mission was explained and they were asked to don the uniform of a plastic anorak. They were then led into six fabric cubicles, each containing a footpad that enabled them to steer their viewpoint in a virtual world by shifting their weight. Each participant viewed this virtual world projected onto a 'rain curtain', a screen composed of a fine water spray. Participants explored the world, communicating over a live audio link,

until they found their targets, at which point an actor would step through the rain curtain, appearing to emerge from the virtual world, and hand them a swipe card. Later on, the participants would step through their curtains, regroup, climb a narrow corridor covered in sand, to enter a reconstructed motel room where they used the swipe cards to access recorded interviews with the six targets. Sometime later, participants would discover that small boxes of sand had been left behind in their coat pockets.

Fig. 1. Desert Rain's cubicles, rain curtain and hill of sand

An ethnographic study documented the design and experience of Desert Rain [20], focusing on how a team of actors and technicians collaboratively orchestrated the experience from behind the scenes. The study described how this team employed various technologies to monitor participants' actions and subtly intervene when necessary in order to maintain their overall journey through the experience. This included dealing with key moments of transition such as when participants physically regrouped after traversing their rain curtains, and also subtly manipulating participants in the virtual world so as to maintain the pace and schedule of each experience.

UNCLE ROY ALL AROUND YOU

Our second experience, Uncle Roy All Around You (2003) also combined virtual worlds with physical sets and props, but this time within the wider environment of the city streets. Having purchased a ticket for an hour-long performance, participants ('street players') would arrive at the host venue to be informed that their task was to explore the city in search of a mysterious character called Uncle Roy. They would leave behind their personal possessions (including money and phones) in return for a handheld computer that guided them through the city via a series of location-based clues. These clues were often highly ambiguous and sometimes implicated passers-by in the performance. They would also receive guidance from remote 'online players' who inhabited a parallel 3D virtual model of the City, could track their progress, and could communicate with them using a combination of text and audio messages. As the journey unfolded, street players would be invited to engage with physical locations and props within the city: removing a postcard from a bicycle's saddlebag; exploring an office; and ultimately getting into a car where a live actor asked them to make a promise to a stranger. Sometime later, each player received a postcard with the details of a promise made by another player.

Thematically, URAY tackled issues of trust and surveillance surrounding location-based technologies. An ethnographic study of performances in three cities focused on how players combined self-reported positioning, everyday navigation competencies and directions from remote players (and sometimes from passersby) to establish an overall trajectory through the city and how once again, this was monitored and shaped from behind the scenes through a process of collaborative orchestration [13]. These studies also informed a discussion of the various performance roles at play in the experience, especially how its deliberately ambiguous framing implicated that bystanders were involved, generating suspense and intrigue, but also raising risks that required careful orchestration [4].

Fig. 2. Uncle Roy's office, car, and virtual city

FAIRGROUND: THRILL LABORATORY

Our next experience takes us to the more mainstream setting of the amusement park, one that will be familiar to many of us. Fairground: Thrill Laboratory (2006) aimed to extend high intensity amusement rides to address the needs of spectators as well as of riders. The motivation was that not every person in a group wishes to go on every ride, and that some visitors (often those who paid for the tickets) end up 'holding the bags' while others enjoy themselves. How might their experience be enhanced?

A degree of spectating is already incorporated into many amusement rides through the provision of spectator galleries at key viewpoints. Thrill extended this by developing a wearable personal telemetry system that captured close-up videos of riders' faces and audio recordings of their talk (and screams), along with acceleration and heart rate data that might potentially indicate their levels of arousal, gathered from wearable sensors. This data was transmitted to large public displays deployed during a series of performance events. It was also used to generate personal 'data souvenirs', videos with sensor data overlaid, that were given to riders afterwards.

This system was initially deployed on three hired rides as part of a public performance event at a major science centre. A study of this experience revealed how the introduction of the technology redefined the relationships between different performance roles [24]. First, it helped transform riders into active performers who would enthusiastically commentate on their experience. Second, it helped transform spectators into an engaged and responsive audience. Third, it transformed the ride operators into event orchestrators, responsible for managing the performance and interpreting data as well as for operating the rides. The

whole experience of riding then involved a trajectory through different roles, for example from being a member of the audience to subsequently performing on the ride. Seasoned operators commented that the experience was 'old school' in the sense that that they felt more closely connected to riders and spectators, as used to be the case with traditional smaller fairground rides. However, the study also highlighted the need to selectively reveal riders' reactions, for example while one rider was asking for the ride to be stopped so that her friend could dismount and the operators were deciding how to respond.

A second version of the technology, enhanced with galvanic skin resistance sensors, was subsequently deployed on Oblivion, the 'world's first vertical drop rollercoaster' at a major amusement park and embedded into an extended rider experience in which groups of riders got to review their own an each others' videos and data.

Fig. 3. Thrill: Fairground Laboratory on Oblivion

DAY OF THE FIGURINES

Day of the Figurines (DoF, 2007), was a text messaging adventure game for mobile phones in which players used SMS to control a character as it lived through a day in the life of a fictional town, visiting destinations, observing events, undertaking missions and chatting with others.

In order to accommodate the slow and infrequent nature of text messages, DoF was designed to be a slow game in which the twenty-four hours of time in the narrative were played out over twenty-four days of the players' real lives, requiring them to send and receive just a few messages each day. The game followed a scripted storyline in which scheduled pre-authored events were interspersed with interactive multiple-choice dilemmas and missions. Each character remained active in the game when their player's phone was unavailable, with the player receiving notifications of any missed events the next time they reconnected. The experience was delivered as a touring performance, being booked to run at a hosting venue over a particular twenty-four days, during which time it was active for ten hours a day while the venue was open.

A further important feature of DoF was that, like Thrill, it deliberately provided an interface for spectators. This was situated in the host venue in order to frame engagement with what was otherwise a largely invisible experience. On arrival at the venue, prospective players encountered a series of tables. A first smaller table (Fig 4, left) contained rows of small plastic figurines. Players were encouraged to

pick these up, inspect them and ultimately choose one to represent them within the game. Having registered their details at a web terminal, players then took their figurines to a second larger table portraying the fictional town (Fig 4, right), with key destinations marked and their silhouettes cut out and raised up from its metal surface. A game operator took their figurine and placed it at the edge of the board ('on the edge of town'). After a short while, the player received their first text message and play began. Every hour the game operators updated the positions all of figurines on the board, guided by digital augmentations in the form of arrows projected onto the surface of the board to show the required movement for each.

Fig. 4. The Day of the Figurines spectator interface

A study of DoF as experienced by over 750 players as it toured to Berlin, Singapore and the UK revealed how the large majority played episodically due to shifting patterns of phone use and personal preferences, dipping in and out of the game, and sometimes disappearing for several days before reengaging [5]. While many appreciated this slow episodic mode of play, it did raise challenges. Messages could be delayed for hours before being delivered due to network congestion, lack of coverage, or phones being switched off, and there could be floods of messages when players switched their phones back on after a break. These factors made it difficult for players to maintain social relationships and a common complaint was of being ignored by others. Finally, players also enjoyed reviewing their histories of play on a website after the game.

While diverse in their specific details, our four experiences share many common features. They connect multiple physical and virtual spaces; adopt well-defined time frames and schedules; connect different performance roles such as participants, spectators and orchestrators; and embed computer interfaces into complex ongoing experiences. We now begin to discuss how an extended notion of trajectories can help us compare them and understand how each operates as a complex and yet coherent whole.

CONTINUOUS TRAJECTORIES
We begin with the fundamental idea of trajectories. We propose that the essential unifying characteristic of our four user experiences is that they take their participants on journeys. While these journeys may pass through different places, times, roles and interfaces as we discuss below, they maintain an overall sense of coherence; of being part of a connected whole. These journeys are steered by the participants, but are also shaped by narratives that are embedded into spatial, temporal and performative structures

by authors. They are also influenced by the dynamic process of orchestration as repeatedly highlighted by our four studies. Finally, they may be undertaken by groups and/or involve encounters among participants.

We consider such journeys to define continuous trajectories through the structures of a user experience. Each participant follows their own trajectory, which may be shaped and steered, and may cross those of others. Trajectories appear to be continuous, extending backwards in time to reveal a coherent history of experience, and forward in time to suggest anticipated routes and possible future actions.

Why is continuity such an important issue? The answer lies in the extended nature of our experiences, especially their embedding of digital media into extended physical spaces. In contrast to the use of conventional PCs where users tend to remain seated at one location, all four experiences require participants to travel through physical spaces: constructed sets in Desert Rain; the city streets in Uncle Roy; the space of the ride, museum and amusement park in Thrill; and an arrangement of tables in DoF. Any journey through physical space takes noticeable time and is experienced continuously.

This approach of thinking of experiences in terms of continuous trajectories is in direct contrast to one of the most familiar computer experiences today, the World Wide Web, which adopts the paradigm of hypermedia where discrete elements are interconnected into complex structures using hyperlinks. Traversal of hyperlinks is near instantaneous, in marked contrast to our experiences here in which the unfolding journey through space and time is a primary aspect of the experience.

In looking beyond the 'discrete but connected' towards the 'continuous and interwoven' we have taken inspiration from the anthropologist Tim Ingold who, in his recent history of lines [17], has drawn on fields as diverse as geography, genealogy, music, drawing, calligraphy and weaving to argue for the benefits of thinking in terms of interwoven continuous lines rather than discrete networks. With reference to the tradition of wayfaring, Ingold argues that it is the experience of the journey that matters more than the final destination. He concludes his book with the observation: "as in life, what matters is not the final destination, but all the interesting things that occur along the way", an observation that resonates strongly with our view of the user experience. The purpose of cultural user experiences is not to reach a destination, solve a problem, or complete a task, but rather to enjoy an engaging journey.

THE HYBRID STRUCTURE OF EXPERIENCES
We now turn our attention to the structure of the experiences through which these trajectories run. Drawing on dramaturgy and its analysis of the structure of performance through space, time, plot and character [23], we propose that the structure of interactive user experiences

consists of four key facets that then combine together: space, time, roles and interfaces.

Space

We begin by considering one of the most fundamental aspects of the user experience: the spatial structure that defines the 'stage' upon which it takes place. A notable feature of our experiences is their creation of hybrid spaces that connect physical and virtual environments into various configurations. Desert Rain places a virtual world at the hart of an extensive physical set, with its rain curtains providing permeable boundaries between the two. Uncle Roy connects a city with a parallel online 3D reproduction, enabling street and online players to communicate between the two. Day of the Figurines connects a textual virtual world to a physical tabletop model.

These extended spatial structures combine virtual reality [26] with ubiquitous computing [30] (originally proposed as the antithesis of virtual reality). They reflect elements of mixed reality with its continuum of possibilities for overlaying the real and virtual, including augmented reality and augmented virtuality [22]. However, they place far less emphasis on seamlessly overlaying the two, but rather establish complex hybrid spaces that connect multiple physical and virtual spaces in different ways: sometimes they are *adjacent* with participants moving from one to the other in sequence; sometimes remote but *connected* with participants communicating between them; and sometimes *overlaid* so that both are experienced simultaneously. The net result is a complex hybrid structure of connected and layered spaces that provides the stage on which the action unfolds. Participants then follow trajectories through these hybrid spaces, repeatedly crossing from one to the other.

Time

Our experiences also have distinctive temporal structures. Desert Rain and Uncle Roy begin at a set time and last for a fixed duration. Players are constantly reminded of how much time remains in order to build dramatic tension, and considerable attention is paid to keeping participants on schedule, including speeding them up and slowing them down through the orchestration process. The temporal structure of Thrill and of amusement parks in general is dominated by the issue of throughput, needing to squeeze as many participants as possible through short intensive experiences, raising issues of ticketing and queuing. DoF has the most complex temporal structure of all, mapping 24 hours of fictional time onto 24 actual days, with limited opening times at the hosting venue, and being affected by the shifting temporal patterns of players' daily lives.

The temporal structure of user experiences is therefore also hybrid, combining multiple timeframes that span story time, scheduled production times, and participants' personal schedules. A previous study of DoF has concluded that this hybrid time involves five distinct layers [5]: *story time* defines the temporal structure of the underlying fictional

universe of the story as conceived by its author; *plot time* defines the order and timing of a particular narration of events from the story universe; *schedule time* describes when these are actually made available to participants; *interaction time* concerns when participants are wiling or able to interact with these; and *perceived time* concerns how participants ultimately reconstruct an overall sense of the timing of the story as a result of these interactions. As with spatial structure, creating a complex and yet coherent user experience involves constructing trajectories through this hybrid temporal structure.

Roles

Our experiences involve a variety of performance roles that define how different individuals are intended to engage with them. The central role in each is that of the *participant*, a member of the public who is the main target for the experience. Some experiences define multiple kinds of participant, e.g., street and online players in Uncle Roy.

A second key role is that of the *spectator*, a member of the public who witnesses the actions of participants, perhaps because they are waiting their turn, do not wish to directly take part, or are just passing through the locality. Several of our experiences deliberately address spectators. Thrill enhances spectating by providing a detailed view of a rider's experience. DoF's tables are designed to attract spectators, intrigue them, and ultimately engage them in the game as participants. A previous study of Uncle Roy discussed how it could be witnessed by passing members of the public, leading to the further specialization of the spectator role into the *audience* who are part of the performance frame (the set of structures and conventions that define its boundaries and enable people to interpret what is happening) and *bystanders* who are not, and who may therefore be unwitting observers [4].

Our experiences also include several professional roles including *actors* who perform to members of the public, for example in the briefings in Desert Rain and Uncle Roy, interpreting data for the audience in Thrill, and moving figurines across the table in DoF. Then there are *operators* and *orchestrators* who manage technologies and shape the experience from behind the scenes.

Each role might be associated with its own kind of trajectory through an experience; for example, participants may pass through different places at different times when compared to spectators or actors. Moreover, an individual may also follow a trajectory through several different roles as part of their overall experience. One common trajectory is from bystander to spectator to participant and back again. On arrival, people are initially unaware of how to interpret what they are seeing (bystanding), but then become increasingly familiar with what is taking place while waiting (spectating), to ultimately take their turn (participating). A second common trajectory is from orchestrator to actor, for example Uncle Roy's street performers monitor participants at a distance (orchestrating)

before stepping forward to offer help (acting). Thus, the multiple roles in an experience themselves form a hybrid structure through which people establish trajectories.

Interfaces

In interactive experiences, the structures of space, time and roles are connected by one further structure, that of computers and their interfaces. All four of our experiences involve diverse collections of interface.

First there are the interfaces used by the participants: rain curtains, and swipe cards in Desert Rain; PDAs and PCs in Uncle Roy; wearable sensors in Thrill; and mobile phones in DoF. Then there are interfaces for spectators: large projected displays in Thrill; the table in DoF; and a large public display in the hosting venue that showed the virtual world in Uncle Roy. Finally, there is a plethora of interfaces to support orchestration including PCs displaying maps and slaved views from participants; stations to register new participants; interfaces to particular pieces of software and hardware infrastructure, walkie-talkies, and so forth.

Diverse interfaces are assembled into local ecologies [16] and people follow trajectories though these. For example, the two tables and associated web terminals in DoF are carefully arranged within the physical space of the hosting venue to establish a trajectory of interaction through them. From the moment of first seeing them, the intention is to catch the eye and then engage the observer on a journey through the various tables, that ultimately engages them in the experience. Interviews with the designers revealed how the position, alignment, lighting and physical form of the interfaces are all carefully chosen to create such a trajectory. Carrying a physical figurine between the different displays may also serve to emphasise the sense of continuity associated with this trajectory. Trajectories through local ecologies of interfaces can be found in other settings too such as amusement parks, where each ride involves a trajectory through a series of interfaces.

TRANSITIONS AND TRAVERSALS

While trajectories through an experience are ideally continuous, maintaining continuity can raise significant challenges in practice. There are critical moments in an experience at which users must cross between spaces, rub up against schedules, take on new roles, or engage with interfaces, which need to be carefully designed if continuity and therefore coherence is to be maintained. We capture this in the idea that there are key *transitions* in each trajectory, moments at which, for whatever reason, continuity is at risk. Experience designers need to be aware of these moments and at have at hand strategies for dealing with them. We identify the following key transitions.

Beginnings and endings

The first important transition is the beginning of the trajectory that frames the entire experience. Beginnings must be designed to introduce the narrative, build suspense, brief participants, and deal with practical concerns such as

ticketing and admission. Our examples show how an experience actually begins with the first point of contact, when a bystander begins their journey towards becoming a spectator and/or participant. Ticketing, queuing and admissions should therefore be designed to be an integrated part of the experience. Techniques here include deploying spectator interfaces and carefully rehearsed ritual briefings.

The transition out of an experience is also a key moment. This may involve the (re)exchange of equipment and personal possessions. It may also encourage participants to reengage with experience, but through a different trajectory For example, Uncle Roy provides public terminals at the venue that encourage street players to stay around and become online players. There is also a need to enable subsequent reflection and discussion through the use of souvenirs and replay interfaces: the box of sand in Desert Rain, the postcard in Uncle Roy, the souvenir video from Thrill, and viewing a personal history on the web in DoF.

Transitions between roles and interfaces

Transitions into new roles may involve further briefings to instruct participants, establish mood, and hand over equipment, testing that it works and instructing participants how to use it. Interfaces should be designed with fluid handover in mind. In Uncle Roy, an actor starts the PDA interface, tests it, hands it over and demonstrates it as part of a briefing. In Thrill, the time consuming process of donning the wearable telemetry system is carefully rehearsed so that it serves to raise tension and suspense. Helpers of an appropriate gender must be at hand if intimate bodily contact is involved (e.g., attaching sensors to skin under clothing in Thrill).

Traversals between physical and virtual worlds

There are several techniques for handling the spatial transition into and out of virtual worlds, best seen in Desert Rain. First, the design of the virtual world is extended outwards to encompass the space within which it is embedded, i.e., the virtual reality technology is placed in a purpose-built physical set (as we also see with simulator rides at amusement parks). Second, participants are isolated from physical distractions, in this case through the use of fabric cubicles. The switching on of the rain curtain gives an effect of the virtual world suddenly materialising in front of the participant. Finally, participants and actors can physically pass through the curtain, creating the illusion of stepping into and out of the virtual world. In this regard, the rain curtain is an example of a physically traversable interface, other examples of which are discussed in [19].

Temporal transitions between episodes

A long-term or ongoing experience such as DoF will involve episodic engagement in which participants repeatedly disengage and reengage. These too are important moments of transition. The experience of DoF showed that reengagement can be difficult with participants needing to catch up with any missed action while potentially being

annoyed by floods of messages. Techniques are required to summarise missed action and perhaps also to better support participants in scheduling and managing episodes.

Transitions into physical resources
Another important kind of transition involves gaining access to key physical resources such as Uncle Roy's office and car. There is a natural constraint on how many copies of such resources there can be (there is only one office and one car) and they need to be carefully shared out to avoid contention if they need to be experienced in isolation or can only accommodate limited numbers. In this regard, physical resources are fundamentally different from virtual ones that can be readily replicated. The orchestrators in Uncle Roy invested considerable effort into slowing down and speeding up players on the clue trail so that they would not arrive at the office and car together.

Transitions across seams in the infrastructure
Finally, there is a further class of transition arising from constraints in the underlying infrastructure that supports an experience. Limitations in network coverage resulted in participants in Uncle Roy and DoF suffering frequent disconnections. Disconnections may require careful interface design to reveal the state of connectivity to players and orchestrators and to help the latter predict where players might have got to in the meantime. Such gaps in the ubiquitous infrastructure have previously been referred to as *seams* [9], and various techniques have been proposed in the literature for dealing with them including removal, hiding, managing, revealing and even exploiting them as a resource in the experience [3,9].

MANAGING TRAJECTORIES
Interactive experiences enable each participant to define their own trajectory, making individual choices and following personal routes. However, this is not an entirely free choice. Artists carefully define one or more ideal routes through the hybrid structures of each experience as part of its overall narrative. Desert Rain always begins in the briefing room and ends in the motel room, and even the apparently free exploration of the virtual world is shaped by orchestration. Similarly, street players' explorations of the city in Uncle Roy are expected to follow one of a few envisaged or ideal routes, and significant divergence from these becomes a concern for orchestrators.

There is a fundamental tension between an author's ideal trajectory through an experience and a participant's actual trajectory, with orchestration being required to resolve the two, enabling participants to temporarily diverge from and reconverge with the pre-established path. Previous work on trajectories in time introduced the term *canonical trajectory* to describe an author's intended route and *participant trajectory* to describe a participant's actual route [5], terminology that extend to cover all of the aspects of an experience. We emphasise the importance of orchestration to maintain an acceptable alignment between the two.

INTERWEAVING TRAJECTORIES
All four of our experiences involve collaboration between participants, either as physically collocated groups or as remote partners. Indeed, our previous discussion of bystanders suggests that any experience in a public setting brings the potential for collaboration, even if accidental.

We can express the nature of collaboration in multi-user experiences by considering how multiple participants' trajectories interweave with one another. As continuous threads, trajectories might approach, cross and leave one another multiple times. As they approach, so participants should become increasingly aware of each another, be able to communicate, and affect each other's experience. This idea is familiar in spatial terms, but also applies to the other structural aspects of experience: time, role and interfaces. For example, [5] proposes how participants could encounter one another across 'story time' leading to new possibilities for shared narratives. We might also steer similar paced trajectories together, so that participants who move through an experience at a similar pace (e.g., show similar patterns of episodic engagement in DoF) will be able collaborate.

However, while it may often be desirable to bring trajectories together, it is sometimes equally important to steer them apart, either to avoid competition for limited resources, or to minimize distractions and interruptions; 'full on' collaboration is not required all of the time. Desert Rain involved key spaces when the six players were brought together (the briefing and motel room), but also others at which they were isolated and kept apart (the virtual world where they started at different positions). Uncle Roy encouraged collaboration between street and online players while avoiding contact between street players, especially at the office and car. Regrouping players is also an important moment; the study of Desert Rain reported how the performers had to carefully control the regrouping of players beyond the virtual world in order to reduce chatting and sustain tension. Different combinations of trajectories need to be steered together at some points but steered apart at others to create the 'social fabric' of an experience, ensuring that it moves between moments of collaboration and isolation, in itself a powerful dramatic tool, or that some combinations of players are in contact while others remain separated.

Finally, each individual may be involved in many ongoing experiences which might affect one another. DoF provides an example of a long-term experience that needs to be interwoven with other activities. A player's trajectory through DoF is interwoven with the trajectories of their other work, family and social experiences. Trajectories from different experiences might also be steered together or apart, for example bringing the trajectory of a cultural experience to the foreground in moments of downtime from work and vice versa.

A CONCEPTUAL FRAMEWORK FOR TRAJECTORIES

The previous sections have explored how trajectories can help explain the nature of complex user experiences. They have discussed different facets of this concept, refining the core idea into further ideas that between them, form a conceptual framework as summarized below.

A **trajectory** describes a journey through a user experience, emphasizing its overall continuity and coherence. Trajectories pass through different **hybrid structures**.

- multiple physical and virtual spaces may be adjacent, connected and overlaid to create a **hybrid space** that provides the stage for the experience.

- **hybrid time** combines story time, plot time, schedule time, interaction time and perceived time to shape the overall timing of events.

- **Hybrid roles** define how different individuals engage, including the public roles of participant and spectator (audience and bystander) and the professional roles of actor, operator and orchestrator.

- **Hybrid ecologies** assemble different interfaces in an environment to enable interaction and collaboration.

Continuity must deal with various **transitions,** key moments at which trajectories cross the seams in hybrid structures. These must be carefully designed and managed.

- **Beginnings** frame an experience, through attracting attention, admission, briefing and handing over equipment as part of the framing of the experience.

- **Endings** use souvenirs and replay interfaces to support reflection, discussion and sharing memories.

- **Role transitions** and **interface transitions** also involve handing over equipment and further briefings.

- **Traversals** between real and virtual worlds are enhanced by matching physical and virtual design and through traversable interfaces.

- **Temporal transitions between episodes** involve periods of disengagement and subsequent reengagement and require succinct summaries of missed action.

- **Transitions into physical resources** that cannot easily be reproduced must deal with contention, while **transitions across seams** must deal with limitations in the underlying technical infrastructure.

Managing Trajectories involves resolving the tension between **participant trajectories** and authors' intended **canonical trajectories**. Processes of **orchestration** help maintain an appropriate degree of alignment between them.

Interleaved trajectories express the collaborative aspects of experiences, including possibilities for **encounters,** managing **pacing,** the need to **separate** participants, and to **prioritize** different ongoing activities.

PUTTING TRAJECTORIES TO WORK

How might this conceptual framework help researchers and practitioners engage with these new kinds of experience? We now explore four possible uses of our framework.

Providing sensitizing concepts for empirical studies

Our initial aim has been to provide empirical researchers with sensitizing concepts to guide studies of user experiences. In the words of Blumer, a sensitizing concept provides a "general sense of reference and guidance in approaching empirical instances" [6]. Or as Bowen has recently put it, they can act as "interpretative devices and a starting point for a qualitative study" [7]. Sensitizing concepts can help inspire new studies, suggesting domains to study or themes on which to focus, and can provide an analytic lens through which to look at data from these studies, or indeed from past studies.

In this paper, we have taken an initial sensitizing concept – that of interactional trajectories – that had emerged from previous research and, by applying it retrospectively to previously published studies of user experiences, have extended and refined it, drawing out many of its subtle nuances. We propose that the resulting conceptual framework can help researchers identify key themes for future studies of cultural experiences. The following are some immediate possibilities:

- Studying how continuity is established and sustained in complex user experiences, including revealing the causes, effects and management of breakdowns in continuity due to different kinds of transitions, building on previous studies of seams and their effects.

- Studying how ecologies of interfaces are assembled, and the nature of trajectories through multiple interfaces that are situated within a surrounding environment, rather than through single interfaces.

- Exploring the temporal interleaving of multiple ongoing experiences and the nature of episodic engagement, including how participants prioritize competing activities and how they manage, interruptions, accountability, and reengagement.

- Deepening our understanding of how experiences are framed, from the practicalities of scheduling, admission and flow in high-throughput experiences, to the role of rituals and briefings and the nature of giving instructions.

Future studies might look beyond 'cutting edge' artistic projects for evidence of trajectories in more mainstream applications, for example amusement parks, tour guides, museums and galleries. Our framework might also sensitize studies outside of the immediate domain of cultural applications, perhaps in learning, the home, or the workplace. To what extent can these experiences also be understood in terms of trajectories?

As a vehicle for compiling craft knowledge

There is clearly already extensive experience of designing complex user experiences, but much of it remains 'craft knowledge', painstakingly acquired by artists, designers and performers over years of practice in which they have iteratively refined their ideas and techniques through multiple projects. Such craft knowledge is currently passed onto the next generation of artists and designers through an apprenticeship model, for example through the common approach of interns working on projects. Our conceptual framework marks the beginning of an attempt to collect and collate such craft knowledge and to distil its key lessons. Even in the relatively short space available in this paper, we have been able to draw together several example experiences embodying a variety of relevant practices, techniques and technologies spanning for example, performance and orchestration; tangible and spectator interfaces; and novel spatial and temporal structures.

One use of our conceptual framework is therefore to support the compilation of key techniques and examples, both from practice and the literature, in order to ultimately establish design guidelines or 'interaction design patterns' [27] for specific aspects of the user experience. From a research perspective, our framework also integrates concepts from the literature including virtual reality [26], ubiquitous computing [30], mixed reality [22], the temporal aspects of interaction [5], tangible and public interfaces [15], seamful design [9] and interface ecologies [16].

Identifying requirements for new technologies

In addition to helping collate existing techniques, reflection on our framework can also reveal gaps where there are requirements for new interaction techniques, tools and platforms. The following are three immediate possibilities.

- We currently lack techniques to support the fluid disengagement from and reengagement with ongoing long-term experiences. We require new techniques to help participants schedule episodes of engagement; to predict likely engagement from their patterns of activity; and to summarise missed action upon reengaging.

- In spite of the use of souvenirs and simple histories, there is a gap for new tools and techniques that can record complex user experiences and then make these available to participants for reflection and discussion. Indeed, it is not even clear what it means to record such an experience, how can we capture all relevant interactions and events in hybrid experiences?

- Orchestration is clearly an important process. However, each new experience currently relies on its own bespoke interfaces for monitoring and intervening in experiences. We require tools that can more easily (perhaps even semi-automatically) generate orchestration interfaces from the specification of an experience. Orchestration tools also need to deal with the dynamic scheduling of limited physical resources.

Enabling a dramaturgy of interactive user experiences

As HCI increasingly engages with practicing artists in order to explore new forms of cultural user experience, so it becomes important to consider whether it also needs to engage with those academic disciplines outside of HCI that have traditionally studied such experiences. The field of drama or performance studies is one such discipline, being fundamentally concerned with the integration of narrative, live performance, sets, props and other technologies to create compelling live experiences. This field involves dramaturgy, the art or technique of dramatic composition or theatrical representation, i.e., the craft that shapes and studies the principal structural elements of a drama or performance. Conventionally, dramaturgies have focused on the drama or action represented on a stage, concentrating, for instance, on practitioners' use of space, time, plot, story, and character within that action, and its effect on an audience [23].

Ideas from dramaturgy have shaped our framework and potentially have much to offer HCI. In turn, the emerging forms of interactive user experience that we discussed in this paper have created the necessity for new dramaturgies in performance and theatre studies that are able to interpret interactive experiences, multi-user platforms and hybrid forms [14]. Our framework is intended to bridge between HCI and performance studies, acting as a *boundary object* [25] that establishes a common language to support new interdisciplinary perspectives on complex interactive user experiences.

CONCLUSION

An emerging generation of artists has been at the forefront of creating powerful new kinds of interactive user experience; and where artists lead, the mainstream often follows. This paper has reflected on several published accounts of such experiences within the HCI literature in order to try to understand what 'makes them tick'. How and why do they work and what does this say to HCI?

We have approached these studies guided by the sensitizing concept of 'interactional trajectories', the idea that an interface can establish a trajectory towards and through it [15], or that its user may craft their interactions so as to establish such a trajectory for others [29]. We have argued that trajectories are indeed an excellent lens through which to view user experience, but also that this concept needs refining and expanding in order to be able to explain the complexities of experiences that are extended over space and time and that involve multiple roles and interfaces, but all assembled into a coherent whole.

The result of our reflections is a new conceptual framework for trajectories in HCI. Our framework draws together key concepts of relevance to understanding and designing experience including: continuity and transitions; hybrid structures of space, time, roles and interfaces; balancing participant and authorial control in interactivity; and interweaving trajectories as an approach to collaboration.

We hope that our framework will provide sensitizing studies for new studies, help us convert craft knowledge into design guidelines and patterns, identify requirements for new technologies, and finally, lead to a new dramaturgy of interactive performance.

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