Augmenting Amusement Rides with Telemetry

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ABSTRACT

We present a system that uses wireless telemetry to enhance the experience of fairground and theme park amusement rides. Our system employs wearable technologies to capture video, audio, heart-rate and acceleration data from riders, which are then streamed live to large public displays and are also recorded. This system has been embedded into a theatrical event called Fairground: Thrill Laboratory in which riders are first selected from a watching audience and their captured data is subsequently presented back to this audience and discussed by experts in medical monitoring, psychology and ride design. Drawing on our experience of deploying the system on three contrasting rides, during which time it was experienced by 25 riders and over 500 audience members, we reflect on how such telemetry data can enhance amusement rides for riders and spectators alike, both during and after the ride.

Categories and Subject Descriptors

C.2.4 [Computer-Communication Networks]: Distributed systems – client/server, distributed applications; J.5 [Arts and Humanities] – Performing arts

General Terms

Design

Keywords

Amusement rides, fairgrounds, theme parks, telemetry, spectator interfaces, thrill, physiological monitoring, heart-rate, electrocardiogram, ECG, accelerometer, wireless video and audio.

1. INTRODUCTION

The amusement park, including the theme park and the fairground, represents an important and historic form of entertainment where mass participation and technological innovation have traditionally worked closely together. The continuing development of ever more exciting visitor experiences within amusement parks has provided a significant driver for many forms of entertainment technology. Whilst the earliest amusement rides were simple manually-operated roundabouts (or "dobbies") [4], modern amusement rides are becoming increasingly dependent upon substantial amounts of computing technology. The use of digital technologies is prominent both during the design process, where simulations of rider experience are often employed before physical prototypes are produced, and during the ride experience, where automated ride control [6] and computer-controlled lighting are becoming commonplace. In fact, one could argue that we are now witnessing an increasing merger between the technologies of the amusement ride and those of the computer game, most notably with the advent of virtual reality simulation rides such as Disney's Aladdin, which makes use of "a high-fidelity virtual-reality experience" to provide the experience of flying a magic carpet through a virtual world [2].

In addition to becoming an increasing integral part of designing and controlling amusement rides, digital technology is also being used to augment the overall ride experience by automatically producing souvenirs in the form of photographic images that can subsequently be purchased by riders or their families and friends. Indeed, larger rides now routinely use digital cameras to capture key moments of the experience [13]. Of course, the nature of still photography means that only a limited visual snapshot of the often much longer ride experience can ever be captured – yet the installation of such cameras in theme parks throughout the world provides evidence of the substantial added value that is associated with this strategy.

The installation of cameras on rides is just one example of a broader strategy that has been widely applied throughout the entertainment industry, which is the provision of entertainment to audiences of spectators by revealing interesting, exciting and unusual features of personal experiences. This strategy works particularly well when such experiences involve activities in which prospective audiences may be unlikely to take part, perhaps because they are too dangerous or too expensive. As examples, broadcasters provide an insight into the experience of driving F1 racing cars by integrating live onboard-video and telemetry feeds into their coverage of motor-sport [7], and skydivers have documented their experience using helmet-mounted cameras [8]. In each case, video and audio technologies yield an insight into thrilling individual experiences that can then be shared and enjoyed by others.

We are interested in exploring how emerging digital technologies, especially telemetry, can be used to extend and augment amusement rides to allow the experience to be shared by others and also to be retrospectively enjoyed by riders themselves. Specifically, we argue that amusement rides can be emotional and dramatic events with the potential to provide significant entertainment for audiences (family members and friends often attend without riding) and yet static photographs cannot capture anywhere near the full richness of a rider's experience. We therefore turn to real-time telemetry systems to capture a richer record of a ride. We describe the design and initial deployment of a prototype system that captures video, audio and physiological measurements from individual riders before, during and after a ride. When using our system, individual riders wear a helmet-mounted AV system, and a jacket augmented with physiological sensors, with data from these various sources being transmitted live over a selection of wireless protocols to nearby public displays. Once received, this data is processed, and can then be presented to an audience through the use of a number of real-time visualizations or recorded for later use. Our system has been tested on three contrasting fairground rides as part of Fairground: Thrill Laboratory, a series of educational and entertainment events involving live audiences.

2. STAGING THE EVENTS

Fairground: Thrill Laboratory (F:TL) was a series of six events that were staged in October and November 2006, on three successive Tuesday and Wednesday evenings, and which were hosted by the Dana Centre at the Science Museum in London. These events were intended to provide both an educational and an entertaining experience to a paying adult audience. F:TL was conceived and curated by Brendan Walker at Aerial, who was responsible for the overall event, including both its overall theatrical structure and its artistic content. The origins of F:TL are in his earlier work on the *chromo11* project, which made use of ethnographic and criminological techniques to develop a taxonomy describing the psychological and sociological components of thrill. The results of this project were published in T*he Taxonomy of Thrill* [5], in which Walker outlines a method for monitoring a thrilling experience by measuring the magnitude and rate of change in arousal and pleasure. Further inspiration for F:TL and its telemetry system was provided by the *Punters* project [11][12], which investigated the use of physiological measurements to trigger the capture of still images at key points in individual experiences.

2.1 The three fairground rides

Central to each event was a fairground ride, and a different ride was chosen each week. Each ride was intended to provide a distinctive kind of thrilling experience, and an overview of each is provided below.

The Miami Trip: This was chosen to provide a thrilling but pleasurable experience, and features a design which aims to encourage interaction between riders and spectators. It consists of a horizontal bench of 16 seats, which is slung between two powered, synchronized rotating arms, one at either end. This bench rotates in a circle, and always moves in a vertical plane. The ride operator expertly controls speed and direction, which can be modified to provide a wide variation of experiences. The bench is arranged so that the riders face any spectators and the success of the Miami Trip lies in the close proximity created between these two groups. The ride that was used in F:TL is shown in Figure 1 and Figure 2 below.

Figure 1 The Miami Trip

Figure 2 Rider position

The Ghost Train: This was chosen to provide an experience containing elements of anxiety, allowing the link between these two emotions to be explored. The Ghost Train that featured at F:TL was three-tiered, and utilized a number of separate carriages to carry 2 riders up a steep incline and then down through a series of tunnels. Although speeds and accelerations encountered by the Ghost Train rider are often much lower than in other amusement park rides, it still provides a uniquely thrilling experience through the use of darkness, actors and props to startle and discomfort riders. The ride used in F:TL is shown in Figure 3 and Figure 4 below.

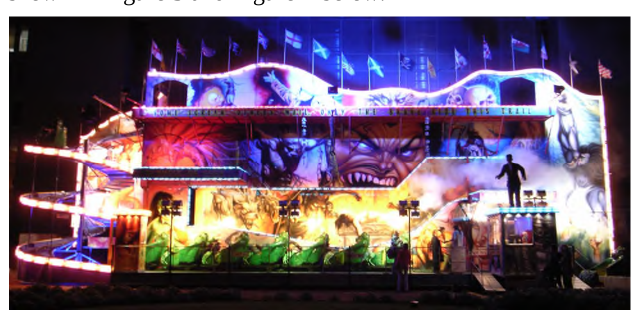


Figure 3 The ghost train

Figure 4 Rider position

The Booster: This is a pure white-knuckle ride that relies mainly upon fear and on extreme accelerations to elicit a sense of thrill in the rider. The Booster featured at F:TL was a brand-new ride imported from the company KMG [9] in the Netherlands. It consisted of a central tower supporting a 40m-long rotating arm. Freely rotating carriages were attached at either end of the arm and held two pairs of riders seated back-to-back. The speed and direction of the ride could be controlled, with riders experiencing accelerations reaching up to 4g. The Booster is shown in Figure 5 and Figure 6 below.

Figure 5 The Booster

Figure 6 Rider position

2.2 Embedding the rides in the event

Each of these rides became the centerpiece of a theatrical event in which riding became a live performance that was deliberately staged for a watching audience. This was achieved through the use of a custom-built telemetry system, which captured and transmitted four data streams, consisting of (1) video of a rider's face (2) audio as a means of rider self-reporting, (3) rider heart-rate and (4) rider acceleration. These data streams were presented to audiences through a number of different visualizations, and were also recorded for later analysis. Visualizations included: (1) a projection of the data in the style of a scientific analysis tool (2) a simpler visualization that gave an overall impression of a rider's experience, and (3) a large impressionistic image that was projected onto the surface of the building itself. In addition, each event included talks by scientists and ride designers, dramatic performances, and themed video, music and food. Early in each event, one of our performers was asked to experience the chosen ride whilst fitted with our telemetry equipment. Later in the event, an audience member was selected to experience the ride in the same manner, and the capture and display of both of these live experiences provided a focus around which expert discussion and audience interaction could be structured.

2.3 Event structure

Each event consisted of both tightly-scripted and less-directed activities, which together lasted for approximately three hours. Events took place in the Dana centre, a diagram of which is shown in Figure 7. Audience members began arriving around 6 pm, with the first talks taking place at around 6:30pm and the final fairground ride taking place just after 9pm. Food and drink were provided throughout the evening, and scheduled activities included introductions to the personal, sociological and scientific nature of thrill and the design of fairground technology.

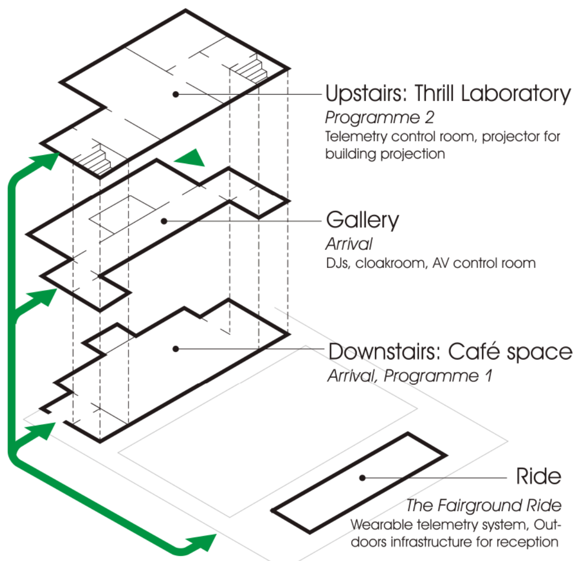


Figure 7 Dana Centre locations used in the event

All three sets of events were structured slightly differently. What follows is the description of the final event, which focused on the Booster.

Arrival: Visitors arrive downstairs at the Café space in the Dana Centre where they are served with themed food and drink by 'thrill technicians', actors who help to frame the overall event in a laboratory context. Visitors are also shown a video installation, compiled from both archive footage held by the National Fairground Archive [10] and other contemporary clips.

Programme 1: After a welcome speech by an event manager from the Dana centre, a video presentation is shown, which is intended to provide an introduction to the evening. This is followed by an introduction to the programme by the curator. Visitors then fill in lottery tickets, which are used later to select an audience member to become a rider wearing the telemetry equipment and therefore the focus of the event. Three short scheduled talks follow. In between the 2nd and 3rd of these talks, the audience is introduced to a professional ethnographer who will be the first to experience the ride whilst wearing the telemetry equipment. The ethnographer then gives a short talk about the social nature of thrill, and the ride is then lit up and spun a few times, to allow it to be seen by the audience through the Dana centre's windows.

Break: During the break, the visitors make their way to an area called the *Thrill Laboratory*, positioned in the upstairs seminar room of the Dana centre. In entering this room, they have the chance to have a first look at the technology control centre, where the telemetry hardware and software are being monitored. This technology is shown in Figure 8.

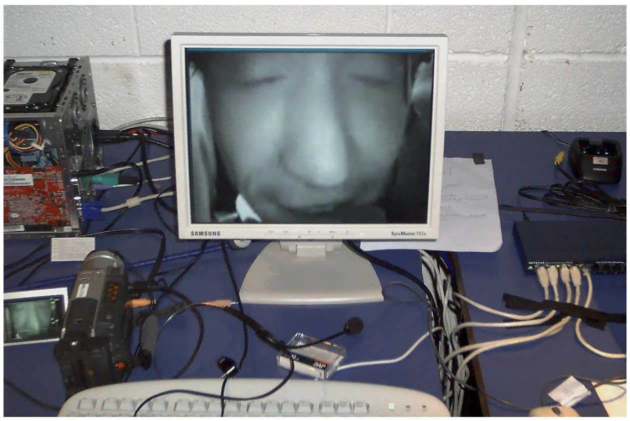


Figure 8 Control centre technology as seen by the audience

Programme 2: The second half of the evening begins with live telemetry of the ethnographer on the ride. The ethnographer talks through his experience, and additional commentary is provided by an expert physiologist, who describes his bodily reactions with reference to the expert visualization. Figure 9 below shows a photograph of the scene in the thrill laboratory. In this figure, the live video is being projected onto the wall on the right of the main projection screen, and his audio feed is being piped through over the room's speakers.

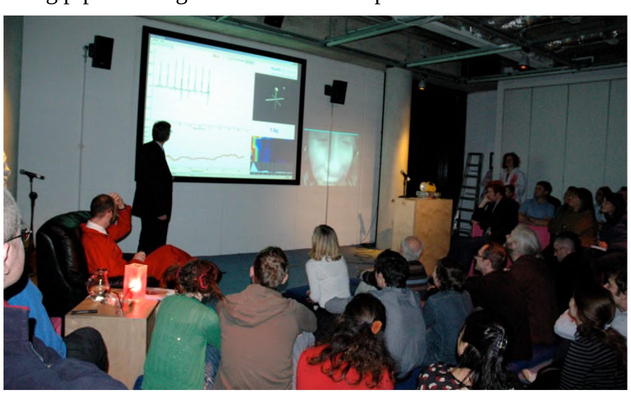


Figure 9 Expert describing telemetry data to an audience

Once the presentation of the data is over, the lottery draw is used to randomly select a member of the audience, who will be the first audience member to experience the ride whilst wearing telemetry equipment. The audience member is then led out to the ride for preparation, and during this process the programme continues with two further short talks. At the end of the 2nd talk, the live telemetry of the lottery winner from the ride is broadcast and displayed as before.

The fairground ride: The audience is now given the opportunity to go on the ride themselves. The downstairs space is transformed into a club with live music (which is also piped onto the ride's PA system), drinks, and the opportunity to talk to the evening's speakers. Open invitations are also made to any visitors who would like to be hooked up to the telemetry system. Live telemetry data broadcast from these individuals is displayed in a non-expert format as peripheral media in the downstairs café space.

3. THE TELEMETRY SYSTEM

The implementation of our technology progressed through the construction of a series of partial prototypes over several months, which were tested through installation on the specific rides that were planned for use in particular events. This process required several visits to amusement parks in the UK, and had to fit in with the commercial pressures that apply to the use of amusement rides stationed in these parks. Multiple site visits were also made to the Dana centre, who co-operated in the design of the physical networking infrastructure.

The key technologies that were exploited in the event in addition to the fairground ride itself are the wearable telemetry equipment and the three different data visualizations.

3.1 The wearable telemetry equipment

The telemetry equipment worn by each individual during F:TL includes a camera helmet and an equipment jacket. Data is transmitted wirelessly via a number of jacket-mounted antennas and received and processed by equipment positioned nearby to the fairground ride. Processed data is then forwarded to the infrastructure positioned inside the Dana centre over a wired LAN connection, and this infrastructure is used to generate visualizations ready for display over the Dana Centre's internal AV system.

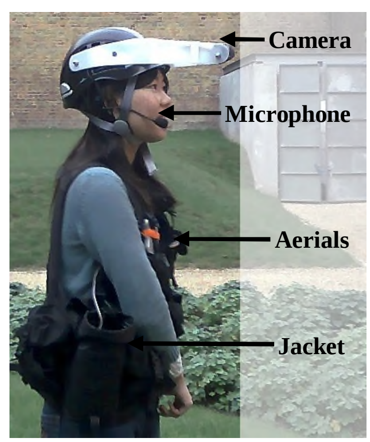


Figure 10 Wearable telemetry technology

Figure 10 shows a member of the technology team wearing the telemetry equipment during pre-event testing. The camera helmet is based on an adjustable Petzl™ climbing helmet. This has been modified to allow a small camera to be mounted away from the rider's face, which points back towards the rider, allowing the observation of facial expressions during the ride. The camera is capable of switching between ambient-light and infrared capture, and has a small inbuilt infrared source. Audio was captured from a boom microphone mounted to the helmet and connected to the audio-in of the camera.

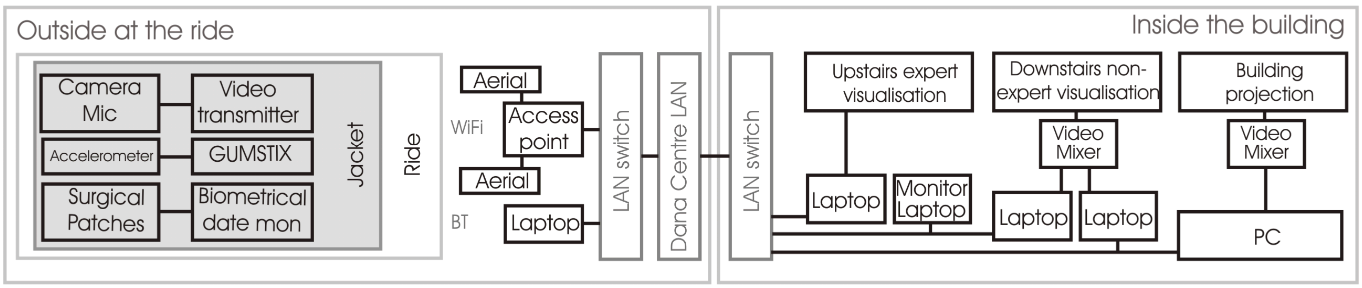
The jacket carries a wireless video transmitter, an accelerometer and a biometrical data monitor. A Neu-Fusion™ Wifi video transmitter, attached to a custom battery back, receives the video and audio streams from the helmet camera, and streams it wirelessly over WiFi as MPEG4. The helmet camera is powered through the same battery pack.

A GUMSTIX ™ computer, powered by a separate battery, wirelessly streams acceleration data from the attached accelerometer over WiFi. A separate Health-Smart biometrical data monitor with its own internal battery streams heart rate and electrocardiogram (ECG) data over Bluetooth. To allow heart-related measurements to be taken, two surgical sensor patches have to be attached to the chests of participants, and these are connected directly to the bio-monitor device.

The rider-worn equipment has to answer several physical design challenges. The equipment needs to be accommodated by each ride's different passenger restraint system, whilst also being comfortable to wear for relatively long periods of time and remain easily serviceable. The design also has to address the added physical strain of wearing head-mounted equipment at high g-forces, the securing of equipment being used on high-speed rides, and the use of body-mounted electrical equipment.

To receive the wirelessly-streamed data, two powerful, waterproof aerials are mounted near to the ride on tripods and attached to a CISCO™ WiFi access point. These aerials are positioned for best reception in front of the ride on the Dana Centre lawn (and, in the case of the Ghost Train, on the ride itself). The Bluetooth signal is received via a small booster aerial attached to a laptop placed in the operator booths of each ride. This same laptop runs data aggregator software which pulls together all numerical data and serves it on request to the different visualizations described below. The WiFi base station and the Bluetooth laptop were connected via a wired hub and fixed CAT5 link into the Dana Centre building, and then onwards into the technology control centre. The technological infrastructure as described above is illustrated in Figure 11.

Figure 11 The technological infrastructure



3.2 The visualizations

Three separate visualizations of telemetry data were used in F:TL, each with a different purpose. They were presented to the audience at different stages of the event and also at different physical locations, as illustrated in Figure 7 and Figure 11.

The first (shown in Figure 12) presents the audience with a multi-panel visualization of the data from the biometrical data monitor and the accelerometer. When using this visualization, video from the helmet camera is projected alongside on a separate screen, and audio is played over the Dana centre's audio system. The purpose of this combination is to enable experts to talk the audience through some of the live data and the physiological experiences the participant is undergoing. This visualization is a central part of the event whilst the ethnographer and the lottery winners are on the theme park ride. A conscious decision was made to maintain and enhance the 'Math-lab' style of remote medical monitoring data visualization provided by project partners Health-Smart as it added to the drama of being in a scientific control centre run by experts.

The second visualization presented to the audience is a non-expert visualization of the data, a screenshot of which is shown in Figure 13 below. Here the live video and audio streamed from the helmet camera are overlaid with a simple visualization of the biometrical data. This is projected in the Dana centre café during the second part of the event. This visualization is intended to be easily read by a novice, and offers an uncluttered representation of data that includes a rider's heart-rate, acceleration and facial expressions.

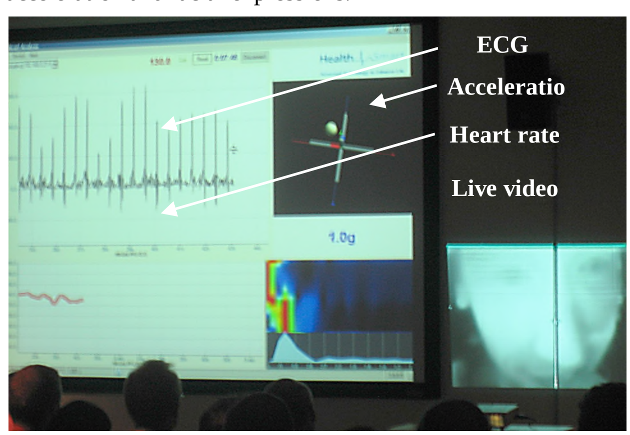


Figure 12 The expert visualization upstairs

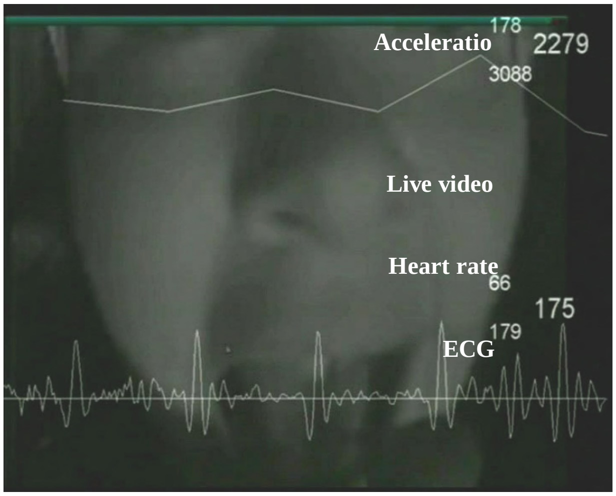


Figure 13 The non-expert visualization downstairs

The third visualization involves a large projection of the live video from the helmet camera on to a building opposite the Dana Centre. This is particularly useful for reminding audience members who are waiting to get on the ride what is to come, increasing their anticipation, and can also be seen from inside the thrill laboratory. This visualization shows the facial expression with streaming binary data overlaid. It is intended to convey the impression that raw data is being streamed from the fairground ride, while also enhancing the visual spectacle of the ride.

3.3 Issues and limitations

Despite the constraints of time and budget, we were able to produce a telemetry system that demonstrated adequate performance and reliability on each of the amusement rides that we applied it to. However, there are some limitations that could usefully be addressed by future development.

First, due to time constraints, the various items of equipment used in the system were only partially integrated. This meant, for example, that multiple transmission protocols and batteries were necessary, which caused some difficulties. In particular, significant work was involved in checking and charging multiple batteries, which also contributed extra weight to the jacket.

Second, there was some signal loss in particular contexts on each ride. The WiFi connection provided by the video sender caused particular problems. Even at very low quality, the video and audio streams provided by the sender tended to be unreliable, although this differed for each ride. The booster, at 40 metres tall and rotating at relatively high speed, posed a significant challenge, which had already been identified during testing. Whilst satisfactory when stationary, the video and audio streams would occasionally cut out when the rate of rotation changed rapidly. This situation was made more difficult by the central London location of the Dana Centre. We traced over 30 WiFi access points in the vicinity, and had to carefully choose an un-congested channel to avoid excessive interference or signal degradation. Although such technology failures could be minimized by allocating time to tune aspects of each installation before an event began, such as the details of antenna choice and positioning, some of the performance aspects of F:TL had to be designed to reduce the impact of potential failures on the audience experience. We believe that F:TL performers successfully negotiated the difficulties inherent in our technology. Indeed, in certain cases we might argue that these difficulties actually enhanced the audience experience, by emphasizing the experimental nature of F:TL.

4. AN EXAMPLE RIDER EXPERIENCE

More than 500 audience members participated in F:TL throughout the three-week period over which it ran, and of these, at least 25 visitors tried out our telemetry and visualization system. In order to provide further insight into the nature of the experience, the structure of the event, the operation of the technology, and its impact on participants, we now present the experience of one typical rider, Jane (not her real name), a lottery winner who rode the Booster during the final F:TL performance.

Jane’s experience began at around the halfway point of the event. With all of the audience collected together in the Thrill Laboratory, her number was drawn at random by an F:TL performer, and she was identified and asked if she was happy to volunteer as a rider. When she agreed, she was given the opportunity to choose one friend to ride with her, and both of these individuals were then led outside. After Jane had left the laboratory, the event continued with further scheduled talks, as described in section 2.3.

Once outside, Jane was introduced to a number of F:TL performers, who began the process of fitting her with telemetry equipment. A female performer attached two sensor pads to her chest, and another fitted her with the telemetry helmet and jacket. Throughout this process, hand-held radios were used by the outside performers to monitor the progress of the ongoing event. Once all equipment had been fitted, and once the outside performers had been given a signal, Jane was led onto the ride and was strapped into it by a professional ride operator. As she mounted the ride, Jane was asked to describe how she was feeling, to which she replied:

> *“I’m well excited actually, and really, really happy that I got picked … I feel very lucky and privileged...”*

An instruction was then issued to the outside performers by radio, and Jane’s visualizations were activated, with one being displayed inside the Thrill Laboratory and another being projected onto the outside wall of the building opposite the Dana centre. Jane was then told that she was live, and she immediately began talking through her head camera and microphone, even though no request had ever been made for her to provide a commentary. We include a partial transcript of her head-cam ride commentary here (taken from our recorded data) as an illustration of her experience. The visualizations of Jane’s telemetry seem to have been enjoyed enormously by those watching in the Thrill Laboratory, who were observed to laugh loudly at various points. It should also be noted that, before Jane’s monologue began, the audience had also experienced a talk by a body-monitoring expert aimed at assisting them in interpreting the data that was being returned by the various sensors to which Jane was connected.

J: um hello I'm sitting on the ride slightly scared but um really excited so it should be cool. If I die I love you all! [heart rate begins to rise from a fairly steady level]

J: The ride's about to start! Ok we're currently going up … Oh my goodness this is amazing this is like the best thing I've ever done … the view from up here is absolutely amazing! [heart rate continues to rise]

J: We're kinda hanging forwards and um we're coming down to the ground we're quite slow at the moment … yeah they're speeding up a bit now [heart rate relatively steady]

J: <loud screaming> Oooh! <loud screaming> ok that was cool <loud screaming> oh my good … <loud screaming> wow! <screaming and exclamation continuing throughout the rest of the ride> [heart rate hits an extended peak of over 170 beats per minute]

J: Ok, we're coming to a stop now. Like that one, yeah, you should give it a go. Woo! Can we go again? [heart rate slowly begins to return to a lower level]

After the ride had stopped, Jane was released, and the telemetric equipment was removed from her. After spending some time chatting to the performers, she was then taken back inside the Dana Centre, where she met others coming out of the Thrill Laboratory who had viewed her performance. Apart from a very short interruption in video and audio during the ride, our telemetry equipment worked well throughout Jane's experience, and we have since been able to reconstruct much of her telemetry for analysis. Our body sensors produced particularly interesting data – Jane's highest recorded heart rate was 179 beats per minute (raised from a level of between 110 and 130 beats per minute whilst waiting for the ride) and her highest recorded acceleration was 3g. Jane was later given a recording of her visualizations, which she has since reviewed and enjoyed.

5. REFLECTIONS

We conclude our paper with some initial reflections on the design of F:TL, especially its relation to contemporary themes in Human Computer Interaction and also the ways in this approach could be extended to enhance amusement rides in the future.

F:TL elicited a very positive response from participants with both riders and spectators expressing great enjoyment of the event. It also stimulated wider interest in the media and the amusement industry, leading to several subsequent requests to restage the event elsewhere, including at a major commercial theme park. Reflecting on the experience, we feel that T:FL was successful because it extended the ride experience in two key dimensions: extending participation by addressing spectators as well as riders; and extending the duration of the experience both in terms of the build up to the ride and also the ability to reflect on it afterwards. We consider each of these in turn.

5.1 Extending participation in rides

F:TL has focused on extending the experience of amusement rides to watching spectators. This reflects an emerging theme within Human Computer Interaction. Motivated by the spread of interactive technologies into public settings such as galleries, museums, and city streets, HCI researchers have begun to consider how to design interaction to be engaging for spectators as well as for direct participants. In particular, a recent paper has proposed a framework for addressing this question based on a distinction between performers (those who are directly using an interface) and spectators (those who are nearby and who may be observing its use) [3]. Designers determine the extent to which a performer's manipulations of the interface as well as their subsequent effects are hidden from or revealed to spectators, leading to four broad design strategies: *secretive*, in which both manipulations and effects are hidden; *magical*, in which the manipulations are hidden but their effects are revealed; *expressive*, in which both manipulations and effects are revealed or amplified; and *suspenseful*, in which manipulations are revealed but their effects (the 'payoff') remain hidden.

F:TL provides an example of deliberately designing a spectator interface. In this case, the performers are our riders. While they do not directly control the ride, they are manipulated by it, through forces creating movements. Applying the above framework, traditional fairground rides are suspenseful in that manipulations are usually revealed (one can usually see the mechanisms of the ride), but effects are largely hidden (it is difficult to appreciate the rider's experience with the exception of hearing the occasional scream). Our telemetry system introduces more expression into rides by capturing and publicly displaying aspects of the ride's effects on the rider for spectators to see. Given that spectators still cannot experience the feel of the ride, the resulting interface falls somewhere between being expressive and suspenseful. Evidence for the success of this approach can be seen in a substantial number of incidents in which our audience members demonstrated their interest and involvement in the live telemetry that they were being shown, including through collective laughter at dramatic points in a ride, pointing out aspects of the visualizations to people sitting nearby, and taking pictures of the visualizations with cameras and mobile-phones.

Furthermore, we can see from our earlier transcript how we have also enhanced the rider experience by enabling and even encouraging them to narrate their experience of the ride to the watching spectators, transforming into performers in the traditional theatrical sense of the term.

5.2 Extending the duration of rides

F:TL extended the duration of the ride experience. Prior to the ride, the public display of other rider's data served to stimulate interest. The process of being selected to be a public rider and subsequently being induced into the experience, especially donning the equipment, appeared to further heighten anticipation. It seems turning a ride into a public event in which the rider is aware of being watched by an audience can dramatically enhance the experience. It is an open question at this time whether the success of this tactic relies on limiting it to just a few riders or whether it would be as effective if each rider was performing to just a small audience, say a few family members or friends.

An interesting feature of F:TL was the number of individuals who asked to see recordings of their own experiences that had been made earlier in the evening. In earlier events, we had not anticipated this, and did not make any public announcements indicating it was possible, yet still many individuals came to find the technical team at the end of the evening, in the hope that their experiences had been recorded and that they could view them. Because of this interest, we made the viewing of these recordings a *feature* of later events, and on several occasions the technical team ended up staying at the Dana centre for well over an hour after the official finish of the event, showing riders their videos, talking through the details of the visualizations that they contained and describing the technical equipment that was required to generate them. In many cases, riders brought friends along with them for this viewing and for these riders, considerable enjoyment seems to have been gained through the use of our recordings as a stimulus during the recounting of personal memories of experiences to their friends. In such cases, we can see how our approach also extends the duration of the experience beyond the moment of the ride itself. Finally, since the event we have also produced several souvenir videos of individual rides which we have sent to the riders concerned.

6. SUMMARY AND THE FUTURE

We have demonstrated how we can use telemetry to transform the act of riding an amusement ride into a theatrical event, extending the experience for riders while also enhancing its entertainment value for spectators. In our case, this has involved capturing video, audio, heart-rate and acceleration information from riders, streaming it to a variety of public displays and then involving different experts to provide insights into different riders' experiences and to discuss the nature of thrill in relation to fairground rides. Initial trials with three contrasting fairground rides have demonstrated that this approach is technically feasible and have yielded initial evidence that it can lead to a powerful experience for riders and spectators.

In the medium term, we propose that it is feasible to extend the still image capture facilities that are already commonplace on major rides to support this kind of telemetry, including producing richer souvenirs. In the longer term, we foresee other exciting possibilities for using telemetry data to enhance amusement rides. First, such data may allow the detailed analysis of the riding experience, enabling designers to understand at precisely which moments riders feel the most thrill and also how different people react to different rides, supporting the more systematic design of more thrilling rides. A second possibility is to design future rides that directly adapt to individual riders' preferences or past history, for example tuning their movements in response to telemetry data, providing a more personalized riding experience than is currently possible [1]. Third, this kind of telemetry system could be used as a marketing tool by enabling amusement rides to be reliably rated for the experience they deliver. The fourth and final possibility concerns extending the spectator experience to include 'tele-riding' through a more immersive presentation of the telemetry data such as a through a 3D simulation that could even be experienced by remote friends and family at a distance over the Internet. We hope that the work that we have presented in this paper helps to inspire similar ideas and so define a new research agenda for amusement rides as a form of entertainment.

7. ACKNOWLEDGEMENTS

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