Touch TV: Adding Feeling to Broadcast Media

Sile O'Modhrain and Ian Oakley

Palpable Machines Research Group, Media Lab Europe
Sugar House Lane, Bellevue, Dublin, Ireland
sile@media.mit.edu, ian@mle.ie

Abstract
In this paper, we discuss the potential role haptic, or touch, feedback might play in supporting a greater sense of immersion in broadcast content and describe some preliminary scenarios we have developed to explore how haptic content might be created and delivered within the context of a broadcast programme. In particular, this work has looked at two potential programme scenarios - the creation of authored haptic effects for children's' cartoons and the automatic capture of motion data to be streamed and displayed in the context of a sports broadcast. We believe that the interactive nature of this touch media has the potential to greatly enrich interactive TV by physically engaging the viewer in the programmed experience.

Keywords
Haptic, touch, interactive TV

Introduction
Since the advent of broadcasting, presenters and producers have sought to reach out across the airwaves and engage their listeners and viewers in an effort to bridge the distances between them. They have endeavoured to provide the sense of being present at the site of a broadcast - giving their audience the best seat in the house for entertainment shows or the opportunity to be on-the-spot for breaking news stories. More importantly, acknowledging that the sense of being present would be greatly increased if the viewer could actively participate in a programme, TV producers have long experimented with ways to give the viewer the impression that they are in control. In 1953, for example, CBS began running a children's series called "Winky Dink and You" [Bukowska, 2001] which is possibly the earliest example of interactive TV. The network made available transparent plastic screen covers that were held in place by static electricity and on which children could draw. During the programme, children were invited to help characters complete crucial tasks by drawing objects on the screen. Unfortunately, this series was withdrawn after four years, primarily because children who didn't have the plastic covers drew on the TV screen anyway.

While many aspects of this example can be questioned from a programmatic point of view – for instance the question of integrity is raised if the hero succeeds in a task even when the child didn't help – it does highlight a number of issues that form useful starting points for a discussion of physical interaction within the context of interactive television. For example, from this scenario we can consider who is generating the interaction, who is controlling the interaction and what the interaction contributes to the sense of involvement in the programme.

In this paper, we explore how physical interaction, and in particular haptic interaction, might enhance and enrich the experience of broadcast content. In particular, we explore the potential for haptic feedback within the context of interactive TV. The scenarios that we have developed, and which are described below, have raised many questions, some of which we address here.

The first, and perhaps the most important issue in situating touch within the paradigm of interactive television relates to goal of the interaction that the haptics are intended to support. In the current state of flux surrounding interactive TV, the term "interactive" has been variously used to describe:

- Interactive synchronous content provided with specific television programs (for instance, the display of textual recipes during a cooking programme),
- Interactive Program Guides,
- Personal Video Recorders

- Bounded interactive programme areas or "Walled Gardens" and
- Multiplexing a number of audio-visual streams within a single channel.

Each of these definitions brings with it an understanding of the kinds of actions the user can perform and the kinds of responses the system should provide. It is interesting to note that the majority of these techniques do little to enhance the "sit-back" scenario of traditional TV viewing, instead altering it into more computer-like "sit-forward" experience, where users interactively interrogate the system seeking information, or controlling devices. Furthermore, none of these application domains really makes use of physical interaction beyond the movement of a cursor-control device or the clicking of a remote control button. And yet the viewer is often holding in their hand an interface that can respond to their actions. In this paper we shall suggest that the infrastructure being developed for interactive TV has the potential to support rich interaction with programme content and that haptic feedback in particular has a significant role to play in this enhancement.

Motivations for Touch TV

While the past 40 years have seen the steady development of techniques for making and broadcasting synchronized audio and video content, little attention has been given to the potential of creating broadcast media for other senses such as touch. However, recent developments in the hardware needed to display touch effects, combined with the advent of interactive television, provide us with a platform for the exploration of broadcast haptics. Moreover, the effects of touch have been examined extensively in a wide variety of virtual environments, and it seems likely that the benefits observed there will transfer to a TV viewing scenario.

The first, and arguably the main, benefit of touch in virtual environments is the effect that it exerts on subjective ratings of presence [Ijsselsteijn *et al.*, 2001]; the level of immersion that it engenders in users. Physically experiencing stimuli creates a powerful illusion of the tangible nature – the reality - of the displayed environment. Supporting this statement, Sallnas et al. [2000] conducted a study looking at user perceptions of their experiences in a virtual environment while completing a task involving moving and interacting with objects. They observed that the addition of haptic cues strongly increased participant's ratings of presence.

Informal evidence supporting this claim comes from the world of consumer gaming technologies where haptic devices in the form of force-feedback joysticks and steering wheels are becoming standard pieces of equipment [Immersion, 2003]. The appeal of these technologies is typically not that the additional feedback will lead to increased skill levels in the games, but instead that players will become more involved and immersed in the game environments; the games will feel more like the "real thing". Similar informal evidence comes from motion simulators, where video captured from a moving vehicle is replayed to viewers seated in capsules that move according to the changes in orientation of the vehicle. For instance, if displaying data captured from a plane, users are physically rotated according to the banks, climbs and dives shown in the video. The addition of this haptic feedback is intended to increase the realism of the simulated journey, drawing users in.

Touch has also been shown to increase ratings of co-presence, the perceived sense of the presence of a distant individual. Oakley *et al.* [2001], Sallnas *et al.* [2000] and Basdogan *et al.* [2000] have all separately investigated the role of touch in co-presence in very different contexts, and independently arrived at the conclusion that it can provide a stronger, and often much more emotive, connection between two distant users than a similar interface lacking a haptic component. It is possible that the addition of haptic cues to broadcast content would enable this kind of increased social connection to take place with characters featured in the displayed programmes. Another possibility might be to increase levels of perceived connection and engagement between viewers of the same programme.

Finally, the role of touch in intra-modal interactions cannot be overlooked. A number of studies have shown strong additive interactions between haptic and visual [e.g. Wu *et al.*, 1999] and haptic and audio [e.g. McGee *et al.*, 2002] stimuli. These studies demonstrate that the combination of an appropriately designed haptic cue with a cue in another modality can lead to a combined cue that is subjectively more powerful. Although this work is ongoing, the conclusion that can be drawn from this research is that the careful addition of haptic feedback to visual or auditory stimuli can provide users with a more intense experience.

Haptic feedback also offers unique possibilities for increasing the level of interactivity in interactive TV. By its very nature, the sense of touch engages us in direct physical interaction with the environment. The hand is the primary focus of our haptic sensory system, and the means by which we typically act on the world. Consequently, acting on an object and sensing its reaction are tightly coupled. As virtual immersive experiences are usually based on the physical world, where we expect and rely on the physical responses to our interactions, the addition of these kinds of cues to broadcast content seems likely to increase viewer's perceived sense of engagement; their inclusion seems likely to make the displayed media feel more interactive.

Haptic cues also fit well into the practical transmission constraints of a broadcast scenario. Although, haptic feedback requires a very high update rate for the production of high quality and stable feedback, the overall bandwidth required is fairly low. Typical haptic interfaces are updated 1000 times a second, but with data consisting of only 10 or 20 bytes per update, yielding greatly reduced bandwidth requirements when compared to video data streams. Consequently, there would be few practical difficulties in including this information in an interactive TV transmission. Indeed, some research has begun to look at the potential for haptic feedback to enhance the expressive capabilities of captioning systems for hearing impaired users [Fels *et al.*, 2001].

To summarise, the literature on touch strongly suggests that it is able to substantially increase subjective levels of immersion and involvement: it has the power to draw people in to a virtual environment. Furthermore, it offers a unique potential for increasing interactivity, and, at least superficially, appears to integrate well into the traditional mode of delivery used for broadcast content. Combined, these properties present a powerful argument for its inclusion in broadcast media.

The Touch TV Project

The Touch TV project is the product of these motivations. It is an ongoing work and involves the creation, and eventual evaluation, of broadcast media containing tightly coupled audio, video and haptic content. A critical part of the project is the theoretical and practical exploration of the various design issues associated with adding touch to an audio video stream. These are discussed in the following sections.

Viewing Scenarios

Possibly the most significant issue relates to how haptic information can be delivered in a viewing scenario. What physical technology can be used to display haptic cues, and how can it be integrated into the living spaces of real users in a non-disruptive fashion? Different haptic devices can produce a wide range of different stimuli from vibration [van Erp, 2002] to skin perturbation [Brenner, 2001] to 6 degree of freedom directional forces [Chen, 1999]. Clearly then, the capabilities of the output devices chosen will fundamentally characterize the nature of the available haptic cues.

In approaching the question of the most appropriate display device for touch TV, we identified certain criteria we felt must be met:

- Integration: the devices must be discreet, and not require users to go to any special lengths to experience the feedback (for instance they must not require users don any equipment).
- Price: as we are examining a mass-market scenario, the cost of the display device must be within the reach of most consumers, ideally less then €100.
- Quality of output: the feedback must be able to convey a rich enough sensation to be valuable across the wide variety of possible viewing topics.

Operating within these constraints, we chose two different objects within which to embed the capacity for haptic feedback. The first of these, which has so far received the majority of our attention, is the idea of a haptic remote control. This decision stems from the fact that for many people the remote control is a constant companion to their viewing experience; it never leaves their hand. This fact satisfies the first of our constraints and makes it an ideal candidate as a haptic display device.

In order to create such a device we turned to the wide variety of haptic technologies available for use in computer games. These devices are typically within the price band identified in our second constraint. Their capabilities range from the ability to produce a controllable sensation of buzz, much like a pager or mobile phone, to those that can actuate directional force along two degrees of freedom. To satisfy our third constraint, and stemming from a belief that directional cues will be vital to the creation of compelling haptic stimuli in this scenario, we selected a device with a small two degree of

freedom actuator: the Gravis Xterminator Force [Gravis, 2003]. In order to make it more suitable for our purposes we re-housed it in a casing of our own design, intended to serve as a somewhat oversized mock-up of a remote control. Both the original device, and our altered model are pictured in Figure 1. Forces are experienced from this device by placing fingers or thumb on the circular joystick visible in both images. This joystick also serves to provide two degrees of freedom input, allowing us to leverage the possibilities for interactivity afforded by the presentation of haptic cues. A final important feature of this display device is that it is restricted to displaying one net force to a single part of the body (typically the fingers) at any given time.

The second display device we are considering is based around a class of commercially available devices designed to augment viewing with haptic feedback. Couch-shakers (e.g. Guitammer, 2003) are devices that are designed to be attached to the underside of furniture, and respond to the bass sounds in broadcast content by producing vibrations of varying intensity. Although they are currently fairly expensive (approximately €500), they do integrate well into a normal viewing scenario as they are hidden within the furniture. In the Touch TV project we intend to uncouple the link between the audio channel of the media and the haptic display, and instead create a dedicated haptic channel. Although the feedback that can be created with these devices is not directional, and therefore not particularly rich, we feel that the fact that it surrounds a user will make its subjective intensity seem very high. Overall, perhaps the ideal hardware platform for this project would be the combination of the relatively rich but subtle information that can be provided by the 2 degree of freedom remote control and the immersive physicality of the couch-shaker. It seems likely that these two forms of feedback would strongly complement one another.

Content Scenarios

As with the creation of any programme content, we can make a broad distinction between that which must be created off-line from that which can be gathered and transmitted in real-time. The issues relating to haptic feedback in each of these two categories are discussed below.

Authored Content

From the wide spectrum of available genres of authored (or manually created) broadcast content, the Touch TV project has focused on programmes for young children, and specifically cartoons

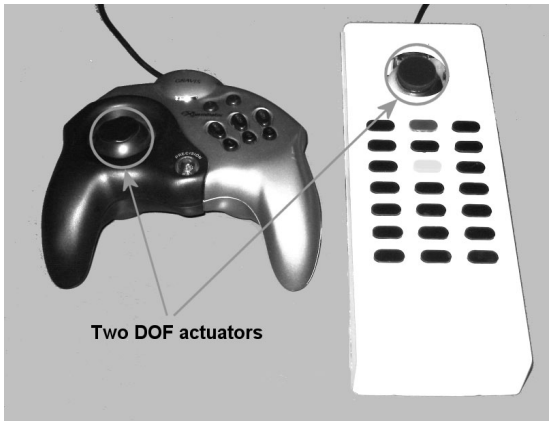

Figure 1. Gravis Xterminator Force (left) and modified remote control handset.

which we call "Touching Tales." There are a number of reasons for this. Firstly, cartoons typically contain scenes that are very physical in nature: protagonists run, jump, fall, push and pull objects and bang into the scenery with an almost alarming regularity. We feel the presence of these kinds of physical actions will be critical to the generation of a set of meaningful haptic cues. Secondly, the creation of cartoons is relatively simple when compared to other broadcast media. For example, cartoons require no filming process, and many no audio recording. The majority of cartoons are also very short. Our final motivation for choosing this particular domain in the initial phase of this project stems from the fact that, as the work of the NexTV TOONS project has illustrated [Bukowka, 2001, Stienstra, 2001], children are very willing to engage with, and even design, novel forms of interactive programme content. For this reason, we believe they are likely to be more open to this novel haptic accompaniment, than a potentially more reserved adult audience.

A further opportunity afforded by the introduction of haptics into interactive TV is the chance to explore the distinction between passively observing and actively interacting with broadcast content. As J. J. Gibson has shown [Gibson, 1962], when we are allowed to actively explore a shape we can correctly identify it 95 per cent of the time, compared with 29 per cent if the shape is pressed onto our passive hand. For Touch TV, this distinction between active exploration and passive reception of touch effects translates into a distinction between reactive haptic effects generated in response to the user's actions and streamed haptic effects that are delivered to the user's passive hand. In the

Touching Tales project, we explore both a reactive scenario, where the viewer can feel and control the motion of a flying bee, and a passive scenario, where the viewer can only observe the forces experienced by an object as it falls to the ground. In line with Gibson's findings, initial informal feedback suggests that viewers find the reactive scenario to be by far the most engaging, because it forces the viewer to physically interact with the content and because their actions on objects are immediately and continually rewarded by the reactions of those objects, just as would be the case in the real world.

Real-time content generation

Our second content creation scenario explores the acquisition and display of haptic content in real time. For this, we chose the domain of live sports broadcasting. This area seems ripe for the addition of haptic cues as the majority of sports place a heavy emphasis on physical interaction. A further beneficial aspect of this domain is that it targets a very different audience to that of our authored content; it increases the general scope of this project. A final reason why we selected sport as a topic for examination is the fact that its viewers crave more detail about the events. This can be observed in the integration of small cameras into all sorts of sporting paraphernalia from the stumps in a cricket game, to the front of a racing car. The viewers of sporting events appear to relish additional perspectives on the action, and this fact suggests that they would readily accept and appreciate the addition of haptic cues.

To explore this domain we have built two systems with the potential to gather and transmit data in real time that could be haptically displayed to a viewer. The first, and most substantial of these, involves the incorporation of accelerometers into a vehicle [Brady *et al.*, 2002]. This allows us to measure and display the accelerations the vehicle experiences, and we believe this would be applicable in a wide range of racing scenarios. Using our directional remote control, this would allow viewers to feel what the driver feels as he or she accelerates, brakes, turns, and bounces over terrain. The couch-shaker technology, on the other hand, could be used to display higher frequency information: the growls and purrs of the engine itself.

The second sensor system we have developed involves the augmentation of a ball with an internal piezo-electric impact sensor. This allows us to measure the collisions that occur to the ball when it is kicked, caught or bounces on the ground. This conveys a strong physical sense of the remote environment, and would be applicable to the vast majority of ball sports. Again, this feedback might be best presented using a combination of the remote control device and the couch-shaker. Weaker impacts could be displayed on the remote control, while powerful impacts (such as a penalty or a shot on goal in a football game) might be most effectively presented on the couch-shaker.

Further Development

From our practical experience gained through the exploration of these scenarios, we can identify a number of topics that require further attention. These are:

- Hardware: although the hardware platforms for display are acceptable at the level of the prototypes we are currently concerned with, more work is required to fully and completely integrate them into a viewing scenario. A number of ergonomic issues still remain.
- Psychophysics: while the psychological literature has much to say regarding the perceptual abilities of the sense of touch when considered in isolation [e.g. Klatzky, 2002], its role in the kind of complex multi-modal scenarios relevant to this work has not been thoroughly studied. Many questions still remain regarding how to best combine touch information with audio and visual data.
- Content creation tools: the development of our haptic cartoon was challenging and time consuming, partly due to the fact that the haptic feedback was very much “bolted-on” to the audio-visual presentation. Dedicated tools that support the creation and integration of haptic cues to broadcast content would be invaluable to this project.
- Improved sensor/mapping systems: although we have developed several systems for gathering real world data for haptic display in a broadcast scenario, these are limited in the situations that they are applicable to. Further work on this topic is required to create a compelling range of automatically generated haptic content.

Future Work

The next phase of this work is to evaluate the prototype systems we have built. Although the arguments for the integration of touch into broadcast content can be convincing, it is important to empirically assess the influence this novel channel of information exerts in this

scenario. To this end, we hope to arrange formal workshop style evaluations, have exhibited our cartoon at a digital film festival [Darklight, 2002], and are actively seeking further exhibition space in which we can gather informal observational data.

Another aspect of this project that we hope to explore in the context of our manually created content is the use of haptic cues by pairs or groups of children. Using the technologies described in this project it is possible to provide a group of children with the same audio and visual story, but provide different haptic cues. The simplest metaphor for this would be to have the focus of the feedback for each child resting on a different character in the story. This would allow the simultaneous presentation of different perspectives, and we hope would result in a dramatic increase in the amount of interaction among children in a viewing group. Such a technology might be able to maximise the social interaction that takes place around a viewing experience, a fact that we feel is important, especially with regard to young children.

Conclusions

In conclusion, we have presented the motivations, the situated design, and several scenarios relating to the addition of touch to broadcast media in order to motivate a general discussion of the potential role haptic feedback might play in interactive TV. The current convergence of broadband connections to the home and wireless infrastructure within the home, alongside the integration of broadcast and internet services provides a unique opportunity to develop devices capable of displaying touch effects, backed up with the infrastructure to support haptic interaction. We feel that the integration of haptic cues into interactive TV is feasible, and that it offers significant potential. In this paper we have presented some of the issues involved in this process, and hope to stimulate research into this novel and interesting topic.

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