Universal Threshold Object: Designing Haptic Interaction for Televised Interactive Narratives

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ABSTRACT
The 'Universal Threshold Object' is a tangible device for television-like interactive narratives based on the TV show *American Horror Story*. The project uses gestural interactions with a tangible controller that provides haptic feedback as an interaction strategy to augment the narrative pleasures of immersion and dramatic agency. We leverage a branching scenario and story-driven gestural interaction with haptic feedback to provide limited sets of interactivity suitable for a television platform. From our research, design goals, and design process, we provide design implications for interactive narratives that employ gestural and haptic interactions.

Author Keywords
Tangible interface, haptic feedback; gestural interaction; interactive television; expressive interaction; threshold object.

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces---*Haptic I/O, Input Devices and Strategies*; K.8.0. [Personal Computing]: General---*Games*.

General Terms
Design; human factors.

INTRODUCTION
Emerging interactive TV platforms offer enhanced interactivity and new possibilities for providing engaging experiences. Looking beyond conventional remote controllers used for channel navigation, more experiential and intuitive interactions are in demand as television converges with more interactive media forms such as websites and games. However, current television program formats remain unisequential, limiting interaction to synchronized second screen polls and informational enhancements. Our research focuses on designing tangible and embodied interactions for next-generation television, which we are assuming will retain its episodic form while allowing for more integrated story-driven interactivity [11].

TEI '15, January 15 - 19 2015, Stanford, CA, USA

http://dx.doi.org/10.1145/2677199.2680563

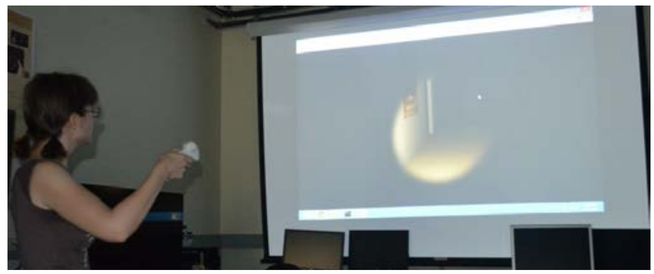

Figure 1: Interaction with the Universal Threshold Object.

The Universal Threshold Object (UTO) is a haptic handheld controller for participatory viewing of an interactive television narrative (see Figure 1). We demonstrate its potential with the TV show *American Horror Story*. The project is based on our previous work, *Don't Open That Door,* which examined in-air gestural interaction with interactive TV narratives [2]. The results of *Don't Open That Door* indicated that using a tangible device might enhance interactivity by providing nuanced information on when to interact, how to interact, and the result of interaction. In order to maximize the narrative pleasure coupled with haptic interaction, our goals were to realize key narrative decisions through physical interaction, to use haptic feedback as a storytelling technique, to prolong emotional decisions, and to reinforce physical presence of the narrative through a tangible interface.

To inform the narrative design, we researched elements of interactive narratives and haptic interactions. Based on our research, prototype design, and user testing, we formulate design considerations for tangible/haptic interfaces for televised interactive narratives: designing interactive narratives for television, providing goals and guidelines for interaction, designing interface and interactions, and designing haptic feedback.

RELATED WORK
The design and implementation of the UTO builds on: (1) interactive narratives particularly within the context of interactive television, (2) tangible and embodied

interactions for narrative progression, and (3) haptic interfaces that augment the narrative experience.

Interactive Television and Interactive Narrative

Storytelling in television is changing as traditional formats converge with new digital media technologies, leading to increasing experimentation with interactivity [7, 10]. Most industry innovation has focused around social media and "transmedia" applications, but a few examples exist of interactive television narratives that allow viewers to interact with stories while they are being told. Storymap is a second screen application that provides tightly synchronized, context sensitive, and character-focused information to enhance comprehension of the series *Justified* [12]. This application supports understanding of the complex character relationships and past episodes for first-time viewers of a late season episode.

There have been explorations on employing interactor's interaction and engagement to lead the narrative progression. The *Gormenghast Explore* prototype, produced by the BBC, enabled viewers to create their own sequences of clips from the popular miniseries, navigating from a 3D model of the Octagonal Gallery in Gormenghast castle. Viewers were able to choose among characters and spaces to develop a unique perspective from which they could comprehend the mystery of the castle [15]. Other examples of interactive television include a prototype for *Battlestar Galactica* episodes created by the AFI Digital Content Lab (2003) that allowed viewers to toggle between watching the television show and being a space pilot defending the ship [9].

While the idea of interactive television seems promising for enhancing viewer engagement, it is challenging to implement due to its complexity for production and requirements for appropriate technical support. If programs progress in a branching narrative, the plot being determined by viewer's interaction in open ended choices, it has to be edited in real time, at the time of viewing [17]. Since software and the interaction replace post-production, the complexity of each program and narrative system has to be planned ahead. The composition, rendering, and delivery requires the viewer's set-top box or computer to have software with processing power to handle the interaction.

With the UTO project, in order to provide interactivity within the constraints of the television broadcasting system, we provide interactions from a first person point of view from the main character of the narrative. The viewer occupies the role of a known character, allowing them to make decisions that affect the lives of characters critical to the show's narrative and motivating them to interact with the narrated environment.

Tangible Interactions with Narrative

Watching television has been perceived as a lean-back (passive) activity, but the rise of interactive television has brought lean-forward (active) viewing experiences, in which viewers assume more involved and social roles. Lean-forward is a term usually used to denote social or second screen interaction and we would like to put forth the term "lean-into" to describe an interaction in a liminal space that is at the diegetic level [6] and part of the unfolding story. The goal is a first person immersion in the dramatic story arc. This viewing experience has potential advantages in that a first person embodied experience may be more immersive, therefore more compelling and pleasurable, and also provide novel storytelling affordances to explore creatively. However, the way this interaction is implemented has been recognized as a potential distraction that prevents viewers from focusing on the linear content. Researchers find that the user interface and interactions need to be designed for fewer interruptions and accommodate a lean-back experience. Vatavu and Zaiti propose using leap gestures for interactions with television [18]. They find that gesture types using hands are more appropriate in the context of lean-back versus lean-forward interaction paradigms with television than are large body movements. Experiments have also been done on using one's palm as a remote control since it eliminates the need to look away from the screen to perform interactions [5].

However, the interactions implemented in the above-described research employ binary or numeric interactions leaving the interactor's performance distinct from the story world. Tangible interface techniques provide gestural or object-based interaction to invite the interactor to be part of the narrative. The Reading Glove [16] uses a glove interface with which interactors pick up different physical objects and hear pieces of stories. As they pick up the objects, they gradually see more information about the story. The physical objects allow the story to progress in diverse ways and also connect the story world with the interactor's physical space. Tangible Comics [14] uses full-body gestural interaction to create a narrative performance and storytelling environment. The gestures the interactor makes and their effects are clearly visualized on-screen through iconic animations. The interactor can also use everyday tangible objects to aid the story's progress. Some researchers have also explored touch and haptic interaction for increasing immersion and involvement, and argue that there are possibilities for employing haptic interaction in home entertainment to enhance engagement with broadcast content [2, 13].

Our UTO project draws on tangible narrative research to design interactions that conform to the narrative, yet strives to tightly couple the input with haptic feedback through the tangible control device to enhance immersion. We provide a single handheld device with haptic interaction, which aims to enhance immersion without distracting from the viewing of the content.

Haptic Interfaces

Haptic feedback as an output method provides feedback for the interaction with the virtual object by applying force or tactile stimulation to the interactor. Haptic feedback has been widely used in movies and games to augment the narrative experience. Danieau et al. finds ways to record video and physical motion to provide haptic effects of motion during movie viewing [4]. The physical motion of activity is translated into force feedback through a Novint Falcon device. A pen, which the interactor can hold, is connected to the torque that gives force feedback. Lemmens et al. made a tactile jacket to make movie viewing more emotionally immersive [8]. Vibrotactile actuators are distributed over the jacket to create patterns that simulate emotional bodily reactions such as goose bumps or shivers down the spine. Alam et al. integrated a haptic jacket, sofa, and wristband with an e-book to provide reading experience with haptic feedback [1]. The system supports three basic emotions: love, joy, and fear. It also incorporates real life scenarios such as bike riding, driving, flying on an airplane, holding hands, and hugging. O'Modhrain and Oakley propose methods to provide rich interaction with broadcast content in the Touch TV project [13]. The system consists of a haptic remote control with a two degrees of freedom actuator, and a couch-shaker for displaying the haptic channel. The work suggests two possible interactive scenarios representing physical actions through haptic interaction. One scenario is authored and reactive haptic interaction with children's cartoons, and the other is real time haptic content of live sports broadcasting.

UTO employs tangible/gestural input together with haptic output to provide emotional or physical feedback for a given scene. The UTO project further explores haptic interaction as a way to affect the narrated plot and enhance emotional engagement with the story world.

BACKGROUND AND DESIGN GOALS

Our research focuses on designing tangible and embodied interactions for a televised interactive narrative. While the technology for interactive television enables viewers to explore diverse narratives, existing televised narrative content is most often structured in an episodic format, where individual episodes have a self-contained plot that provides narrative closure. In order to fit within existing television industry structures, a "lean-into" interactive televised experience should thus adhere to the episodic format of existing shows. Also, to lower the barrier of viewing, it is necessary for those who don't know how or don't want to interact to still be able to view the interactive televised narrative as if it were an ordinary TV show. To meet these requirements, we formulated the following design requirements: (1) The narrative should be segmented and diversified within a self-contained and coherent plot; (2) The story should be able to continue even after failure of the interaction; (3) The interactor should be scripted with expectations to know when and how to interact; (4) The physical actions should be simple, allowing lean-into interaction.

In our previous project *Don't Open That Door* [2], we created a Kinect-based gestural interaction for an interactive narrative based on the horror-drama television series *Supernatural*. We scripted the interactor with verbal and visual cues so that the interactor would know when and how to interact. Despite these visual and verbal cues, we found that interactors were often confused about when to and how to interact, and were unsure of whether or not their interaction was successful. Based on these observations, we hypothesized that tangible controllers coupled with gestural interaction could solve some of these problems by closing the loop between the interactor and the narrative scenario, providing more refined and immediate feedback.

In designing the physical interface for the interactive narrative, we were inspired by Murray's description of a "threshold object" [10]. She argues that an object in the real world, like a game controller or a teacup, can take the interactor across the boundary to the virtual world, and increase immersion by reinforcing belief in the virtual world. Murray further explains dramatic agency as a state with maximized story power, which can be created when the interactor's actions are integrated with the story content. The design of the tangible controller should thus be grounded in the narrative and provide interactions and feedback that are tightly coupled with the narrative.

Based on the insights from our previous project and our research, we designed the narrative, interface, and interactions to meet the following design goals.

- Realize key narrative decisions through physical interaction that results in dramatic agency.
- Tightly couple haptic feedback as a storytelling technique and define a haptic/visual integrated grammar.
- Allow prolonged emotional decision-making in a first person experience.
- Reinforce the physical presence of the narrative through a threshold object and the entering of a liminal space that is part of the diegetic story.

THE UNIVERSAL THRESHOLD OBJECT (UTO)

The UTO is a tangible device for interacting with televised interactive narratives. As an interface, the UTO acts as a changing threshold object, its liminal presence assuming the affordances of key objects in the narrative to reinforce the physical presence of the storyworld in the interactor's embodied space. Narrative decisions are thus realized through physical interaction, which is designed to sharpen dramatic agency by the interactor. The interface provides emotional and physical haptic feedback as a storytelling technique coupled with visual and narrative cues. The haptic interaction also augments immersion by prolonging emotional decisions that the interactor performs.

We chose the 2012 Emmy award-winning series *American Horror Story* as our source for a narrative environment because of its well-established genre elements and its popularity. The horror genre provided us with story patterns that are immediately familiar to members of our target audience and that provide dramatic points of inflection to address with maximum dramatic agency. The horror genre also benefits from haptic experience due to creation of suspense through visual tropes like haunted and dark spaces that have a direct correlation to embodied senses.

The events in the series are tied to dramatic family relationships and conflicts such as a cheating husband whose young lover haunts the married couple. We reconfigured the story elements and situated the interactor in the point of view of the betrayed wife inside of the romantic triangle. Our narrative scenario repurposes the ending of the last episode where the husband is hanged and then reunited with his wife in the afterlife.

The Synlab and eTV lab at Georgia Tech co-designed the device, narrative, and interactions in a collaborative and iterative process. The eTV lab focused on the narrative scenario and visual/embodied grammar, programmed the interactions with the narrative, and shot/edited the interactive video. The Synlab designed the tangible interface and physical interactions. Storyboards, flowcharts, wireframes, foam models, and prototypes were used to share and communicate ideas during the collaborative work process.

Walkthrough

The flow of the scenario/experience is shown in Figure 2. The interactor assumes the role of Vivien, one of the main characters of the show. The video begins with an exposition in the form of Vivien's dream that reveals her continuing to feel disturbed, as she is unable to forgive her husband Ben for cheating on her with his student Hayden. The interactor sees a flashlight being grabbed from a table, and the UTO device vibrates. Then the interactor sees a flash of Ben being hanged and a shot of hands grabbing a rope. There is a close-up of the flashlight on the table and the device vibrates again. The close-up shot of an object combined with vibration of the UTO device is used as an aesthetic grammar to indicate what the threshold device will become.

The video then shows Vivien waking up from her sleep. As she is getting up, Vivien is startled by a glimpse of a ghostly figure. She grabs the flashlight next to her table, and the device vibrates in the user's hand as a confirmation that it is active. The video shows the flashlight in Vivien's hand from a point of view shot to indicate that the interactor is now in control. As Vivien opens her bedroom door the shot fades into a hallway seen from a first-person point of view. Vivien walks down the hallway to find out what is happening.

The hallway sequence starts with the flashlight pointing forward and this creates the onscreen sensation of walking forward (see Figure 3, left). As the interactor points toward each door in the hallway, "she," the interactor, sees different objects through the doors such as jars containing scary objects, a man hanging in a rubber suit, gothic paintings, and bloody graffiti. The UTO vibrates with a heartbeat-like pulse to emulate Vivien's heartbeat and connect the interactor to the space. Pointing the flashlight forward, Vivien arrives at a door at the end of the hallway, and Ben's screaming can be heard.

Onscreen the interactor's point of view is through the door's keyhole as Vivien sees a faint image of Ben being hanged just like in the dream sequence. A close-up of the rope and a hand is shown to indicate the threshold device is becoming the rope (see Figure 3, right). The device starts vibrating continuously to make the interactor quickly realize that it is Vivien who has grabbed the rope. The constant vibration of the device is an indication that she feels the pressure of the rope holding Ben at the other end. Shots of Ben struggling are alternated with shots of hands on the rope. Depending on how the interactor applies or releases pressure on the device, the rope grows tauter (keeping him hanging), gradually looser (slowly lowering him to the ground), or very loose (slipping through the fingers and dropping him quickly to the ground). The scene

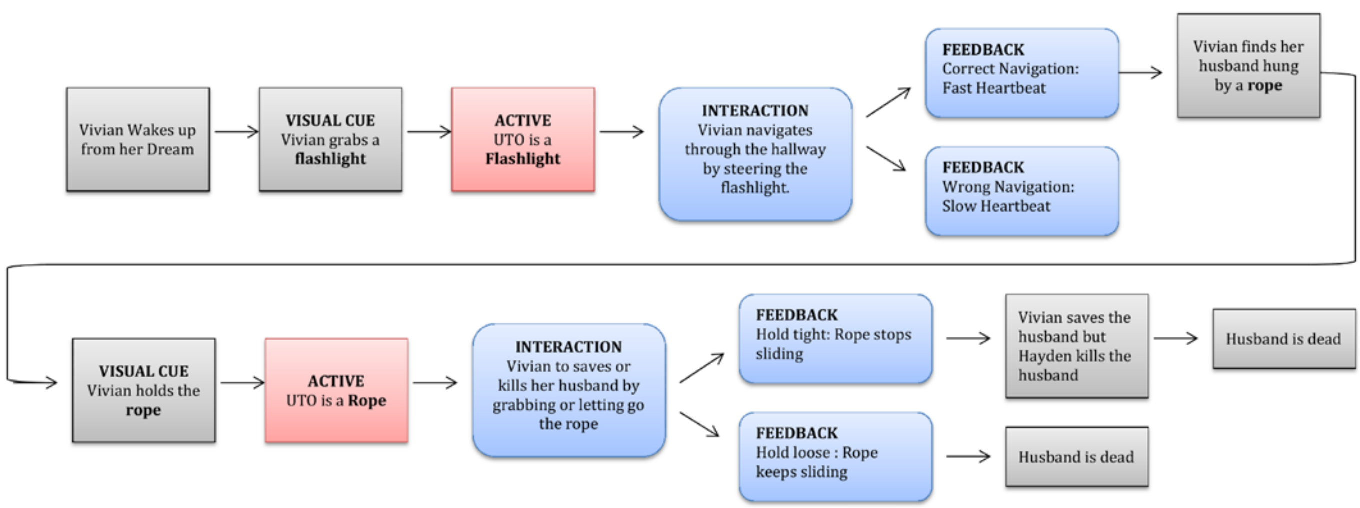

Figure 2: Scenario flow chart

is edited dynamically in response to the interactor's pressure. Haptic responses are paired with visual confirmations in the form of shot sequences that are edited on the fly based on an algorithm responding to the interactor's physical interaction as Ben drops quickly or slowly to the ground. This threshold event places the interactor into the climax of the story with the ability to exert maximum dramatic agency. It is also meant to dramatize Vivien's ambivalence toward Ben, whom she may or may not want to save. The choice is not meant to be logical but rather embodied and immediate as the interactor's actions are given a haptic and visual response.

If Ben hangs to death, we see a shot of his student Hayden, who died previously on the show, feeling satisfied that he too is dead like her. If Ben falls to the ground, we see him die immediately while seeing Vivien feeling shattered. If Ben is brought down slowly and is able to survive, we see Vivien forgiving him. But Hayden then appears suddenly and stabs him to death. Therefore, the end result of the interaction maintains dramatic agency, while making sure that Ben ends up dying in any case, as in the series finale.

Figure 3: Video of the scenes when the interactor is using UTO as a flashlight (left) and a rope (right)

System Design

To fulfill our design goals, we set the following system and story requirements: (1) the interactor should be informed about when/how to interact so that s/he can form reasonable expectations, (2) the UTO should be a single handheld multifunctional device to avoid distraction, (3) objects should be situated to play key roles in the narrative, and (4) the story should progress in a first-person point of view.

To script the interactor with narrative expectations, we structured the initial scene as a passive introduction to the story and interactions. The sequence indicates the upcoming events and interactive grammar that will unfold, complete with haptic confirmations in concert with various shots. Scenes such as flashback, dream, and glimpse are used to provide expositions with visual and narrative cues about what will happen and how to interact without disrupting the narrative. In Vivien's dream, the flashback of her husband's betrayal provides background narrative information and sharpens the dramatic stakes. The dream scene of Vivien's husband being hanged prepares the interactor for the key event that will happen during the show.

When the scene is passive, the story progresses as it would normally in a TV show. When the scene is active, we use visual and haptic cues to signal the interactor, such as a sequence of shots with a close up of a threshold object, first person point of view shots of the character grasping the object, and synchronous vibration of the UTO device (see Figure 4). The scene changes into a first-person point of view in the active scenes. When the UTO is ready to be used, it is set to vibrate while the flashlight or the rope appears in the video.

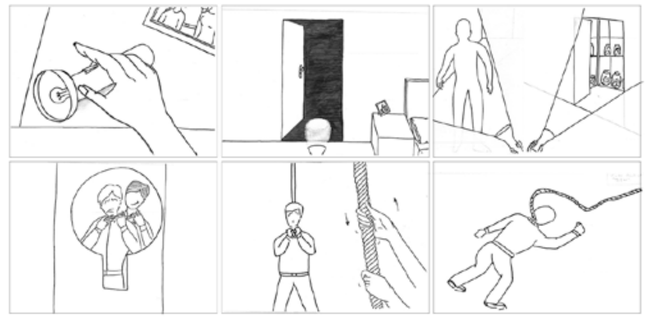

Figure 4: Storyboard for the interactive video

We designed the UTO as a single handheld device with multiple functionalities to prevent interactor distraction (e.g., having to select between different objects to interact with) and to make the haptic interaction useful as a storytelling technique. The form of the device is neutral and generic so that the interactor can mentally connect it to many different objects while holding it. The cylindrical shape of the UTO allows it to be held comfortably with one hand. It can be used as a variety of different objects, e.g. for aiming, grabbing, or pulling, as with the flashlight or rope in our scenario. To provide physical and emotional feedback for the interaction, the UTO vibrates in five different patterns, two for the pulsing heartbeat while holding the flashlight and three for the friction and resistance of holding the rope. The interactor's gestural actions such as steering or grabbing serve as input to change the content of the video and the UTO device provides the corresponding haptic feedback. This closes the loop between the interactor and the narrative and helps the interactor focus on the story without getting distracted by searching for devices or feedback/response in the video.

We progress the story in the first-person point of view of the betrayed character to enhance dramatic agency. The haptic experience provides emotional cues of fear, spookiness, suspense and revulsion. As the interactor continues walking through the hallway, her emotion rises with anxiety, urgency, and suspense and the device vibrates like a beating heart in a pattern that is meant to represent both the pulse rate of the character and the character's nervousness while walking forward in the dark. The haptic experience of the heartbeat helps the interactor empathize and identify with Vivien.

We create dramatic agency by having the interactor realize a key narrative and emotional decision through the physical interaction of squeezing or releasing the UTO as a rope. The amount of force applied by the interactor on the device corresponds to how hard the character holds onto the rope in the narrative. The device vibrates differently depending on the amount of pressure applied, replicating the feeling of a rope sliding through the hand through a coded interaction of pulses to denote different actions.

To provide a prolonged emotional decision, the interactor is required to hold the rope for a certain amount of time, 5 seconds, which consist of dynamically edited shots coupled with haptic feedback in order to proceed. While having to wait and continue, the prolonged emotional decision becomes augmented to a maximal degree. The vibration also stays on during this time to support the prolonged emotional decision.

To keep the interactive plot self-contained and consistent with the series, Vivien's husband must die even if Vivian decides to save him, which is then done by Hayden. This additional irony is also meant to add to the immersive emotions of the haptic experience.

System Implementation

To create the video, we cut footage from various episodes of the first season of *American Horror Story* to provide a bank of shots from which to create clips for our invented events. When we could not match our storyboard with existing shots, we shot additional footage, with and without green screens. The green screen footage allowed us to insert visual elements from the sets of the actual series, creating continuity with the diegetic world. Videos are segmented and can be played in an HTML5 web browser.

To accurately represent the interaction of navigating through a hallway with high-fidelity representation, we used the Unity3D engine. We tasked the Unity application with interpreting the gestures and allowed it to call the correct JavaScript functions in the web browser using the Unity WebPlayer along with the HTML5 video. The hallway space was built as a 3D environment to work with the Unity player and create a space with additional interactive affordances such as looking in doors and peeking around corners.

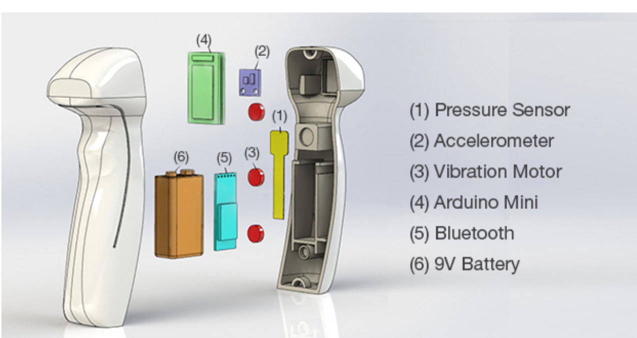

Figure 5: UTO device diagram

The physical interface of the UTO was modeled in Solidworks and fabricated with a 3D printer (see Figure 5). The interface contains a microprocessor, Bluetooth module, battery, vibration motors, as well as a pressure sensor and a gyroscope. The gyroscope is used for the flashlight to be steered and the pressure sensor is used as the rope is grabbed. The controller has three vibration motors placed in a row to create different patterns of haptic experience. The Bluetooth module sends binary signals that are parsed by the server application.

We used Arduino to program diverse vibration patterns. In order to create patterns, we emulate the tactile feedback of a heartbeat and the sensation of holding a rope with a heavy load at the end. By turning on and off the three vibration motors or running them at different speeds, we create rhythmic patterns (see Figure 6). To imitate the pulsing pattern of the heartbeat, three motors are turned on shortly and turned off, alternating in high speed and low speed. To give the feeling of a rope sliding through the hands, we turned on and off each of the motors in a sequence. To depict the horrible moment when the rope is taut and loaded with the weight of the husband who is struggling to live, we run the motors at high speed in a distinct pattern.

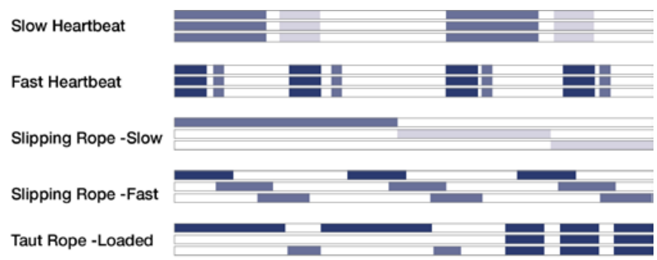

Figure 6: Haptic vibration patterns (the darkness of the color bar indicates the speed of the vibration motor)

The setup requires a computer paired with the UTO interface via Bluetooth and a screen the interactor can view. The computer application consists of three parts: the HTML5 application, the Unity Web Player application and the Server application. The server application sends the serial data it receives from the device to the Unity application, which in turn translates the binary data and calls the correct JavaScript function in the HTML5 application to seek to the correct position in the video.

FEEDBACK AND DISCUSSION

We first showcased the project in December of 2012. We had thirty participants for our pilot user test where they provided us with feedback about their experience using the UTO device. Some of the participants also answered a short exit questionnaire after they interacted with the system. After getting feedback about the first version, we made revisions and released a second version. We report our findings based on feedback about both versions.

The narrative was understood clearly and the initial narrative exposition thus proved to be very effective, as most users had not seen the show before and felt the exposition provided them with sufficient context for the interactions. Almost all the users understood that they had taken the role of Vivien as they saw the dream progress.

Even though we added narrative cues and some visual cues for when and how the UTO should be used, it appeared that some interactors were unable to connect how the interface should be used in regards to the onscreen object. The ambiguous shape of the universal object appeared to be confusing with respect to how it should be held. Even though all the users held the device in the upright vertical position as we intended for the rope sequence, some users also held the device in an upright position for the flashlight sequence, instead of holding it horizontally. Furthermore, the technical constraints required the device to be initially calibrated when held in a correct horizontal position while entering the hallway. When held at a wrong angle, the device calibrated incorrectly, resulting in the character moving in an unproductive direction in the hallway.

Some visual cues appeared to be interpreted incorrectly, and we learned that verbal cues are sometimes more efficient. Some participants felt that the movement of hands in the video of the rope sequence seemed to suggest that the rope could be released by moving the device instead of decreasing pressure on it. Some users did not see sufficient feedback to believe they were in control of the rope, and as a result let the rope sequence play back through its default path. We added a voice over of Ben screaming “lower me gently” to improve this interaction.

In the case of the hallway sequence, which provided freedom to explore, interactors were sometimes lost in the middle. It appears that visual and verbal cues are necessary to inform interactors where they are supposed to go and what their goals are. In our first round of testing, some users did not focus on the door at the end of the corridor, and did not point the flashlight in that direction, which was the input that triggered simulated movement toward the door, where the next dramatic action took place. We added dramatic emphasis in the form of flickering lights and shaking of the door, with audio of Ben asking for help. The second trial, with these changes, was successful in cueing the interactors to point the device straight ahead.

The haptic experience and the threshold object coupled with the narrative gave pleasure to the interactors. Though some found it initially confusing, once they saw the shot sequence of Vivien grabbing the flashlight they felt that the device’s vibration worked well to confirm their expectation of being in control of the device. Also, interactors found the squeezing and releasing gesture from the rope scene appealing. It seemed to present a good emotional match for the action onscreen.

We were limited to providing haptic feedback as iconic vibration patterns rather than realistic representations of tactile sensations, due to limitations of our development period and resources. The haptic feedback we designed was initially not clearly interpreted as intended physical or emotional feedback by interactors. The prototype device mapped different patterns of vibration to events that the interactor controlled in the narrative, but it was difficult for interactors to distinguish between the changing vibration patterns associated with different events and actions. Our revisions intensified the differences in speed, intensity, and rhythms, which made the patterns easier to differentiate.

DESIGN CONSIDERATIONS

Our research suggests that using a tangible device with an interactive narrative can create dramatic agency and provide narrative pleasure to the interactor. The interactor realizes emotional choices through physical interaction as s/he empathizes and struggles with the character. The haptic interface as a threshold object reinforces the liminal and physical presence of the story world, employing haptic feedback as a storytelling technique.

Designing Interactive Narratives for Television

Interactivity on television expands plot varieties. However, the existing episodic structure and content creation and distribution models are not capable of multiple conclusions and require coordination of a branching interactive narrative within a linear television series. There could be several different techniques to extend the plot while adjusting the ending to be consistent. Choosing each character’s perspective to view in a scenario or focusing on specific parts of the narrative are some ideas. Coupling these with the affordances of the tangible interface can add the pleasures of interactivity and narrative exploration.

Providing Goals and Guidelines for Interaction

Interactivity provides agency and pleasure while watching television. However, interactivity can also confuse the interactor about how to interact and what to do. Adding cues and feedback in the video and the haptic interface to imply how to interact can minimize confusion and increase clarity in this new story space. This includes visual, verbal and haptic cues about when to interact, what to do, how to hold the interface, and what gestures to make, as well as about what the haptic feedback means in the story context. Also, it is possible that repeated exposure to this new type of narrative haptic grammar would improve intuitive understanding of the interactions and the cues.

Designing Interface and Interactions

The direct mapping of the interface to the form and function of the object in the narrative helps the interactor understand how to interact. We explored several different forms and interactions that can be expressed through a single handheld interface. We explored a set of actions, such as pulling, grabbing, swinging, triggering, and aiming, which correspond with threshold objects such as rope, rod, sword, gun, and flashlight. During our brainstorming sessions, we used green foam to experiment with diverse possibilities for forms and functions that can be connected to the object. Using green foam let us test how it would be held in the hand and allowed us to explore different poses. We finally chose a combination of flashlight and rope to tie in with the narrative scenario we were developing.

Designing Haptic Feedback

The haptic experience could be improved through refining the haptic feedback and using different materials for the interface. We were limited to providing iconic vibration patterns but there can be other ways to provide more realistic vibro-tactile feedback. In this project we used only vibration motors, but other methods of stimulation such weight shifting, or electro-tactile feedback could give different results. Our interface was made out of 5mm plastic. The thickness and rigidness of the material diminished the sensitivity. Using thin or flexible material for the interface could improve sensitivity.

CONCLUSION AND FUTURE WORK

Our research suggests that tangible objects can create an experience of dramatic agency and increased immersion when integrated with regular television programming. By extending objects from the narrative world to have a physical presence in the interactor's space as threshold objects, we were able to create engaging interactions that reinforced the interactor's immersion in the story. Interactors were willing to accept that a neutrally-shaped handheld haptic device could represent different objects at different points in the narrative.

We see many other areas for productive research in the growing area of interactive television. We plan to extend the project by investigating how the system would work with different genres of stories, or longer and more complicated narratives. In our prototype, the interactor was constrained to a single point of view, but if we let interactors switch points of view, how would this affect dramatic engagement? Although the UTO remains a speculative design rather than a commercial product, it is a useful framework for exploring the evolving design space at the convergence of interactive computing and television storytelling.

ACKNOWLEDGEMENTS

We thank Tawny Schlieski from the Intel Interaction and Experience Research Group for support and collaboration. We also thank our collaborators on the project: Derek Young, Yuan Yuan Lin, and Erin Hennessy from the Synaesthetic Media Lab (Synlab) and Patrick Coursey, Amrutha Krishnan, Benjamin Pincus, Pratik Zaveri, Laurie Marion, Sarah Fox and Toby Smith from the eTV lab. *American Horror Story* Season 1 was produced by 20th Century Fox who holds the copyright.

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