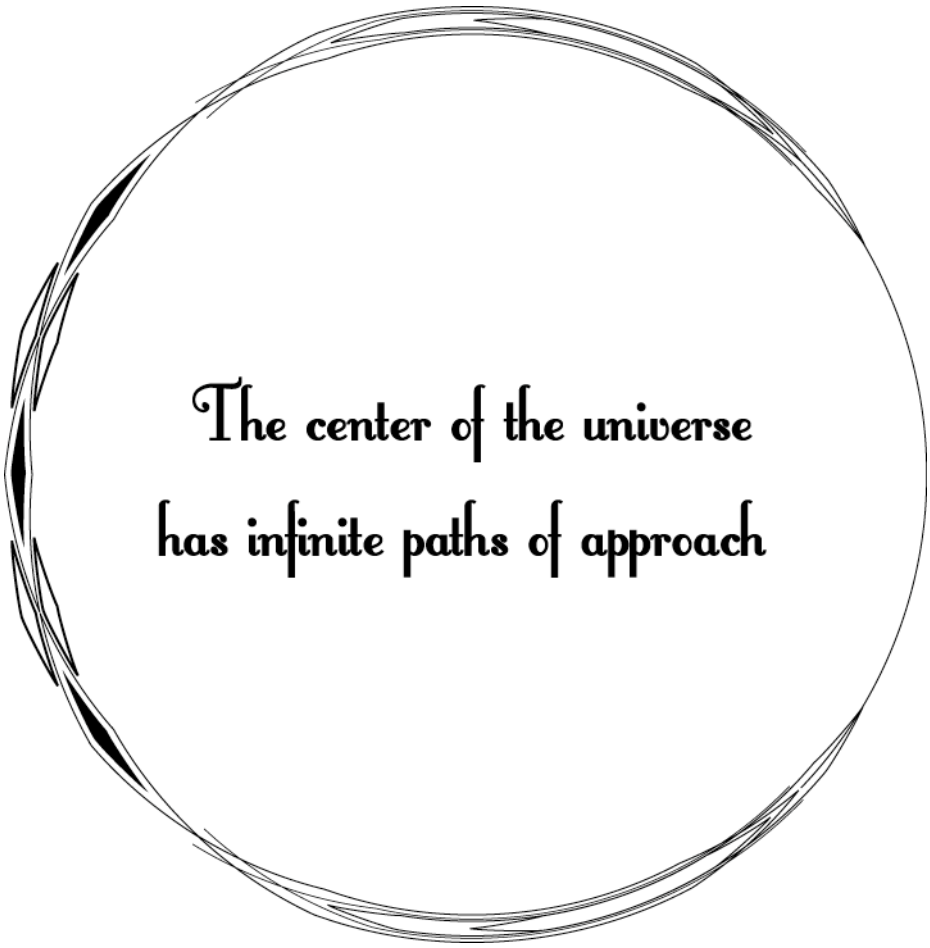

creating non-linear narratives with RFID technology

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introduction: project summary and related works

project summary

The center of the universe has infinite paths of approach is a multimedia installation that utilizes Radio Frequency Identification (RFID) technology and the mythology of Tarot cards to create an interactive, nonlinear narrative experience. The user takes a seat at a custom-built table and shuffles a deck of Tarot cards, choosing 10 cards at random to pass over the table's onboard RFID reader. Each card is embedded with a low-frequency RFID tag that transmits a unique ID number to the reader, which interfaces with a bespoke Actionscript application to queue up a corresponding Flash movie for the scanned card. Once all 10 cards have been selected, the reading begins.

related works

The center of the universe is an exploration of objects, metadata and RFID technology as tools for nonlinear, open-ended storytelling, where users create individualized journeys through a narrative world and are encouraged to apply their own interpretations to the fragments of meaning provided. This approach to narrative can also be seen in hypertext fiction, where the user is presented with a portal into a multimedia universe that must be navigated, rather than merely consumed, to be understood. Like the Choose Your Own Adventure books of the 1980s – although often much more intricate and media-rich – hypertexts offer readers a continuously branching (and sometimes looping and intersecting) path of fragmented text, images and audio to explore. Thus the full story of the constructed world is never actually told, but inferred uniquely by each inhabitant.

Central to the construction of such worlds are typically the objects within them, and the stories encoded within those objects. Says author Shelley Jackson of her seminal hypertext *Patchwork Girl* (Eastgate Systems 1995), "I guess you could say I want my fiction to be more like a world full of things that you can wander around in, rather than a record or memory of those wanderings" (Amerika 1998). *The center of the universe* is a preliminary application of this concept to the physical world, where material objects become keys that unlock interconnected stories.

In this regard the piece shares characteristics with Alternate Reality Games (ARGs), which expand the hypertext model of nonlinear, multimedia narrative beyond the borders of the computer screen and into the material world. ARGs have used a plethora of physical objects as narrative vehicles, some of which have merely served as clever marketing materials announcing the launch of a game (such as the honey bottles from *I Love Bees*, McGonigal 2004), but others of which – such as the collectible cards in the ongoing Perplex City ARG – contain a wealth of cryptic information about the game world (Mind Candy 2007). I believe the

potential is rich for incorporating RFID-embedded objects into ARGs and similar projects, particularly if the technology is integrated into mobile handsets on a mass-market level in the near future, as industry analysts continue to predict (IT Reseller 2007).

In regard to current use of RFID technology, I'm aware of two projects that directly relate to *The center of the universe*: The Symbolic Table and iLand. A third project, Sensitive Samples, has similarities – and has also been inspirational in regard to ideas for future iterations. Also related – as well as inspirational -- is the work of artist Meghan Trainor, who has been using and developing RFID technology within her practice for the past several years.

The Symbolic Table, a project by Willem Velthoven and Andy Smith of Amsterdam's Mediamatic, is billed as a "100% interface-free media player" (Velthoven 2006). The user places an RFID-tagged object on the table and associated multimedia files are played back. Primary hardware design for *The center of the universe* was inspired by The Symbolic Table, which similarly houses an RFID reader and application server under the table. *The center of the universe* departs from The Symbolic Table, however, in its more complex queuing and serving of files. Such behavior is not, to my knowledge, part of The Symbolic Table's design.

Iland is a more commercial and fully-featured project, from Danish developers Cordura. It operates on the same principle as The Symbolic Table, but comes with user-friendly software for programming tagged objects with associated media files and behaviors. It also has multiple "active" zones on the table, and supports complex interactions between pieces and zones.

The Sensitive Sample is project by the Institute of Design and Assessment of Technology at Vienna University of Technology, Austria. It consists of two prototypical design models that utilize a combination of RFID tags and various sensors to create novel learning interfaces for the institute's architecture students. Of greatest interest to me is their prototype still in development, Materialkammer.

> Materialkammer is a room filled with material samples [embedded with tilt and touch sensors] … The room is equipped with projectors, sound devices, fans, lighting equipment... The users enter the room and start exploring the materials. Depending on the way how the users interact with the samples, an atmosphere in the room is created. If someone plays with the wooden samples, and does it in a quite gentle and smooth way, an atmosphere of a wood in spring could be created (Matkovi´c et al. 2004, p. 4).

I find Materialkammer particularly inspiring in its linking of RFID input with multi-sensory output, which I would like to explore in future iterations of *The center of the universe* and in my future work with RFID in general.

And finally, Meghan Trainor's work includes performance pieces such as *16 Horsepower*, in which the artist "scan[s] pieces of ceramic and graphite embedded with RFID tags to trigger different sounds from an audio database" (Trainor 2006). Trainor is also an instrument in the performance, via an RFID chip implanted in her arm. Particularly appealing about Trainor's practice is her use of bespoke "smart" objects that themselves are works of art with a narrative aesthetic, such as the ceramic plumb bobs commissioned for *16 Horsepower* (see Fig. 1). I am also drawn to her performative use of RFID, particularly as it references notions of ubiquitous computing – i.e., removing traditional computing metaphors from user-interface design.

Figure 1: ceramic plumb bobs crafted by Michelle Anderson for Meghan Trainor's multimedia RFID performance piece* 16 Horsepower *(img: Meghan Trainor)

technical background and specifications

background

RFID technology works on a relatively straightforward concept: An RFID tag transmits a unique identifying code (analogous to a barcode) via a specific radio frequency, which can be detected and interpreted by purpose-built readers. The reader passes this translated ID to a middleware application, via a wireless or cabled network connection. The application then typically queries a database (hosted locally or remotely) that contains additional information associated with that ID, and returns the information to the user.

The most basic type of RFID tag is simply a microchip attached to an antenna. The microchip is used to store the tag's unique ID, and sometimes a small amount of additional data. The antenna is used to draw power from the reader device and activate the tag so it can send a signal back to the reader, as simple passive tags (the most common kind) lack an onboard power source.

RFID technology in its most primitive form has been in use since World War II, when its core concepts were applied to the task of identifying incoming planes as ally or enemy. RFID's first widespread commercial implementation was in the 1960s, when the technology was used to create electronic anti-theft tags. The 1980s brought electronic toll collection via RFID, and since the 1990s the technology – paired with the growth of the Internet -- has spawned a massive and still-growing industry utilizing RFID as an international supply-chain management tool (Landt 2001). During the past several years artists and academics have begun experimenting with the technology, as illustrated in the previous section, and will no doubt continue to do so as ubiquitous computing devices and concepts further permeate modern society.

specifications

The center of the universe uses a Phidget RFID reader and EM4102 low-frequency (125 KHz) read-only thin cards, interfacing with an Actionscript 3.0 application built on top of the Phidget AS3 library. The Phidget reader was chosen for its relatively low cost, ease of use, and available software libraries that provide basic functionality between tag and reader (turning on the reader and connecting to a local webhost, recognizing tag ID transmission and loss of signal, reporting errors). The thin cards were chosen for both aesthetic and practical reasons: artistically, they perfectly approximate a blank deck of cards; functionally, they operate at the required read range to penetrate the thickness of an average tabletop without detecting cards outside of the installation's desired active reading zone[1]. The thin cards have the added benefit of being durable and easy to handle, both necessary for a public installation running over the course of several days amongst a student population. Actionscript was chosen as the development environment on the advice that of all the languages supported by Phidgets for Mac OS X (Actionscript, C/C++/VC++, Cocoa, Java JNI, and Max/MSP), it would be the easiest to learn from scratch.[2]

[1] It was discovered during early testing that the read range on 30mm global tags is exceptionally poor, whereas performance of all other commonly available styles of EM4102 tags, including inventory labels, clamshell cards, laminate disks and buttons was practically identical.

[2] While this may be true of Actionscript 2.0, AS3 is a completely new, object-oriented version of the language, and most available support is geared toward developers either making the transition from AS2 or with a solid background in other object-oriented languages. As I fall in neither category, I found it quite a challenge to teach myself AS3 to a fairly advanced level in the span of two months with virtually no guidance.

implementation: application and content development

application development

When I began design of the middleware application I set three goals for function and performance in this iteration: *queuing*, *templating* and *resetting*. All three of these goals have been met, and a fourth goal, *security*, was also set and achieved during development when it became clear that establishing such functionality was a worthwhile research objective. The four core functions of the application will be discussed below, and possible extensions of the application will be discussed in the Conclusions section.

Queuing: The primary function of the application is to accept card IDs into a queue until 10 unique cards have been accepted, then play back the content associated with each card in the order in which the cards were scanned. To achieve this the application uses the onTag function included in the Phidget AS3 library, which reports a card's ID number when the card is detected by the RFID reader. OnTag's functionality was expanded to include a series of conditional statements and loops to push card IDs into an array, checking each ID first to ensure that it is not already present in the array. The application also uses the length of this array as a variable that directs playback of a series of countdown screens informing the reader of the number of cards already selected; that plays a unique chime each time a new card is accepted; and that controls the background music for this opening segment. When the array length is equal to 10, the onTag function ceases to push new IDs into the array, a new "playlist" array is created and populated with the 10 IDs in correct order, and the playhead is sent to the first template screen. (*Please see KILBY_MP.flv on the accompanying CD for the full onTag source code Location: Main timeline → actions layer → Frame 2 → lines 42-273.*)

Templating: While it is true that non-linear narratives are often devoid of the navigational structures typically found in more traditional forms of storytelling, I decided at the outset of this project that incorporating some of the structure inherent to the Tarot would provide a more compelling user experience than providing no guideposts as all. To this end I chose to frame the user experience within the context most commonly associated with Tarot – a "reading" – in which a predetermined number of cards are chosen randomly from the Tarot deck and laid out in a specific configuration, with the position of each card contextualizing the meaning of the card itself. For example, in the configuration I chose to work with, the well-known Celtic Cross spread, the fifth card signifies the near future – or something that may soon occur.

The meaning of these card positions is conveyed to the user in two ways: first, with a very abstract, poetic line of text at the top of the corresponding countdown screen – the precisely intended meaning of which will likely be lost on those who are not already familiar with the

Celtic Cross. This was a deliberate narrative choice. The user is given more explicit guidance with the second templating tool: a scene marker that plays before each card, with explanatory text. For example, the scene marker for the first card reads “Act One, Scene One: The Heart of the Matter.”

The playhead is directed from one scene marker to the next, and to the correct card content to be played after each scene marker, via two scripts – one that lives on each frame of a 10-frame master scene-marker movie clip, and one that similarly lives on each frame of a multi-frame master card-content movie clip. After the scene marker has finished playing, the script uses an integer variable and a loop to check the ID of the first card in the playlist array against a master deck array, which contains the IDs of all the cards in the deck. When the loop function finds a match it sends the playhead to the corresponding frame number on the master card-content movie clip and shifts the ID of that card out of the playlist array. This shift operation at the end of each scene marker allows subsequent scene markers to always treat the zero (first) position in the playlist array as the current card, making for more recyclable code. The shift operation also allows the length property of the playlist array to be used by the card-content navigational script, in conjunction with a loop and an integer variable, to send the playhead to the correct frame of the master scene-marker movie clip when playback of the card content is complete.[3] (*Please see KILBY_MP.flv on the accompanying CD for the full source code of both scripts. Location: Library → screens folder → scene markers folder → mc_sceneMarkers → actions layer → any frame.*)

Resetting: Given the nature of the user interface for this piece (content is displayed via projection, with no access to the laptop server or its input devices), it was essential that the application be able to return to a ready state at the end of each session without any input from the user. This is accomplished via a script on a conclusion screen that informs the user that the session is complete. The script uses a splice operation to clear all card IDs out of the original countdown array that was populated at the beginning of the session, and sends the playhead back to the opening screen of the application. The playlist array does not need to be cleared, as consecutive shift operations on each scene marker have depopulated it down to zero by the time the conclusion screen is reached. (*Please see KILBY_MP.flv on the accompanying CD for the full source code of both scripts. Location: Library → screens folder → fin folder → mc_Fin → Frame 1.*)

[3] Individual scene-marker movie clips are actually placed on their corresponding frames on the master scene-marker movie clip in the reverse order, to allow for correct playback. For example, when the playlist array length is 9 and the playhead is thus sent to frame 9 of the master clip, the movie for Scene Two plays, because 9 cards left in the playhead array means one card has already been played and removed from the array.

Security: During a test run of the application I was asked an interesting question by an observer: “So what happens if I come in here with my own RFID tag and try to scan that?” Given the ubiquity of RFID technology in keyless entry systems, particularly on a university campus, this was actually not an unlikely usage scenario.

The answer was twofold. First, the Phidget reader in this iteration of the installation is designed to read only EM4102 tags, so unless the tag was of this type it simply did not activate the reader. If the tag *was* of the correct type, however, it was accepted into the initial countdown array, then pushed into the playlist array, and ultimately stalled the application when the script on the corresponding scene marker attempted to match the ID against the master deck array and send the playhead to the correct card-content movie.

My initial attempt at addressing this issue involved rewarding the user for thinking creatively, by playing a special movie clip designed specifically for such a scenario. Due to complex scope constraints in AS3 this proved too tricky an approach for my current skill level, however. Instead I wrapped the entire onTag function with a loop that checks each card against the master deck array before executing the rest of the script. If the loop finds a match, the operations described in the *Queuing* section are allowed to proceed. If no match is found the function ends and no action is taken.

While this is an acceptable solution, in future iterations I would like to explore the possibility of delivering content when literal “wild cards” are introduced into the system. Also, while such a security measure is sufficient for read-only systems, research conducted by Vrije Universiteit’s Melanie Rieback has established that read-write RFID systems are vulnerable to virus and worm attacks by a number of methods (Rieback 2006) – not all of which could necessarily be defended against with the approach described above[4].

content development

Due to the complexity of coding the application and my inexperience with AS3 at the outset of this project, it became clear at about a month to completion that the original plan of creating content for all 78 cards of the Tarot would have to be revised. The project in this iteration therefore includes only the 22 cards of the Major Arcana, a subset of the Tarot which is complemented by the 56 cards of the Minor Arcana.

Additionally, it was discovered during the content development phase that a known but unresolved bug prevents Macintosh systems from correctly encoding FLV video files for progressive download by the Flash player. Embedded video will play back successfully, but

[4] It is unlikely that such an attack would be maliciously deployed within the context of an art installation, although these vulnerabilities could be deliberately explored with artistic and critical intent.

such an approach is designed for the inclusion of very short video clips. Further, embedded video does not synchronize well with its audio track and oftentimes completely fails to play, necessitating the inclusion of a separate sound layer on the timeline of the movie clip that contains the embedded video. Unfortunately, synchronizing audio and video by this method is a painstaking and somewhat imprecise process, which further slowed down the production process and resulted in content that is less than ideal in its final form.

conclusion: future plans and findings

future plans

In addition to developing content for the remaining 56 cards of the Tarot deck, I would like to use *The center of the universe*'s application framework to explore the development of an entirely original narrative world, including more fully realized audiovisual content. I would also like to experiment with multisensory output linked to RFID-controlled input; possibilities include lights, fans, scent-release devices, and all manner of robotics.

Last, and in conjunction with my central critical interest in RFID – that identity is a fluid concept – I would like to explore the idea of multiple data sets associated with individual tag IDs. The data returned could be determined by the unique ID associated with the reader itself, or by other variables established programmatically such as timestamp, GPS coordinates, or parameters within a history log for the reader or the tag.

findings

Given the simplicity of RFID technology and its ability to interface with any manner of bespoke back-end applications, I believe it has great potential for continued exploration in both artistic and critical realms. The physical characteristics of RFID (small, lightweight, portable) make it particularly well suited to performance and installation pieces and novel user interfaces. RFID also has enormous potential in mobile application development, if handsets equipped with the appropriate technology ever reach a sufficient level of market penetration. The feasibility of developing mobile RFID applications will be dependent upon a degree of cooperation among industry leaders, however, as a lack of standardization in protocols – particularly regarding the type of tags that can be read – will likely deter any investment in this area.

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