Final Project Report

Group F

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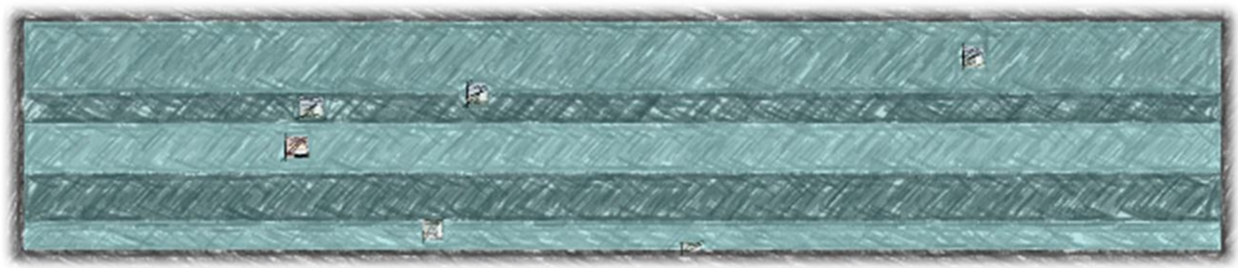

Overview

Virginia Tech's research center in Arlington, Virginia is a seven story installation, which hosts many of the University's most prominent research groups, tasked with the advancement of informatics and data analytics, cyber-security, medical technologies and bio-imaging, and alternative energy solutions. It attracts the attention of major high-tech companies in northern Virginia, as well as military and government agencies.

The structure itself is LEED Gold certified on its exterior and is pending certification for its interior. It is host to spacious hallways and open floor plans which allow uninterrupted line of sight between most points on a given floor. This theme is exemplified on its second floor, which includes an executive conference space and surrounding public areas, including two lobbies (east and west) and a wide corridor lined with lit shadow boxes and staggered heights.

The Charles W. Steger Design Competition, which began on the 1st of September 2011, states as its goal:

> *"...to create a plan for visually enhancing the aesthetics of the common areas of the executive conference space of the Virginia Tech Research Center."*

Our proposal for this design competition is a series of four hands-off interactive displays which react to the proximity of nearby visitors to the research center. Visitors are to be offered special badges and asked to specify what fields of study they have come to VTRC-A with an interest in. Simply passing by one of the four interactive displays while wearing or carrying one of these badges will activate the display, which will present a variety of information about persons and activities at VTRC-A that are custom-tailored to each passing visitor. This hands-off, personalized approach will create a friendly basis for conversation among visitors and offer enticing glimpses into other activities at the research center.

Audience Review

As a host to research organizations garnering special interest from the military, government agencies, and high-tech companies, the VTRC-A frequently hosts visitors who are interested in what the research center has to offer. The conference space, lobbies, and hallway space that are the subject of the Steger Competition are arguably more the domain of these visitors than they are of the researchers of the VTRC-A itself.

Figure 1: A Hallway with the shadow boxes.

The VTRC-A's location in the high-tech Ballston area of Arlington makes it a neighbor of a good number of governmental offices that will undoubtedly express interest in the facility's work, including the National Science Foundation, the Office of Naval Research, and the National Rural Electric Cooperative Association. On top of this, northern Virginia is host to major engineering firms such as Lockheed Martin, Northrop Grumman, Boeing, and others that will likely wish to contract with VTRC-A. The research center's clients will undoubtedly extend to the DoD, CIA, and NSA.

Figure 2: East lobby.

The second-floor conference space, namely its travel space and waiting areas, provide an excellent location for reaching out to visitors from these external agencies in a personalized way. Presently these areas provide a thoroughly day-lit, modern atmosphere that is evocative of the innovation symbolized by the VTRC-A, and their wide open spaces allow for an unrestricted flow through the space. The challenge is in capturing that flow momentarily from the hallway, and keeping its attention in the lobby spaces; visitors to these spaces will most likely have a specific destination to reach within the research center, and are not likely the kind of

Figure 3: West lobby.

people that are easily persuaded to stop and interact with a hands-on information system during their visit.

Concept

To this end, our proposal is the installation of four interactive displays on the second floor; one wide-format displays for each of the two long hallways' alcoves, and one large-format display for each of the east and west lobbies.

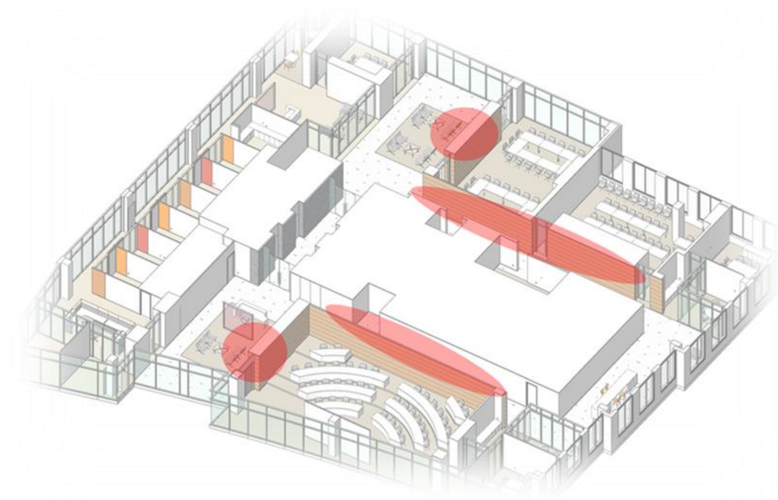
Figure 4: All relevant design spaces.

The two hallways are to be host to a pair of displays that are approximately the shape of one of the hallways' shadow boxes, perhaps as a replacement to one of the shadow boxes themselves. These displays, in their passive state, show a traveling wave of small shapes moving in a uniform direction down the hallway.

The two lobbies are to each contain a single, large-format display, ideally placed into the wall of the space rather than simply hung so as to more seamlessly integrate with the fabric of the space. The displays should allow a person to stand unimpeded nearby, at an ideal reading distance.

Each of these displays are to be reactive to the proximity of a visitor to the VTRC-A. When no visitors are present, the displays remain in a passive state, displaying no personalized information. When a visitor comes near to one of the displays, however, it is to present that visitor information about people, places, and activities at the VTRC-A that are specifically tailored to that visitor's interests. For example:

> *A visitor who comes to the research center with a specific interest in bioinformatics may, when approaching one of the larger-format displays, be presented with an excerpt from a recent article about VTRC-A's bioinformatics research. He may also be shown a short biography of one of VTRC-A's bioinformatics researchers.*

This completely hands-off approach is to be implemented by offering each visitor to the research center a special visitor badge. Each badge is embedded with an RFID (Radio-frequency Identification), and each RFID is to be associated with a set of ***tags*** which describe what that visitor's interests are at the research center. Each display will be loaded with a set of responses to an RFID loaded with a specific (or possibly multiple) tags, and will present relevant information when one of these RFID-enabled badges is detected close by.

Hallways

The first of these displays that a visitor is likely to encounter is one of the hallway displays. The goal of these displays is to quickly capture the attention of a traveling visitor, and to this end, each display will present a literal ***flow*** of information as virtualized particles travel in a uniform direction towards the lobby spaces at approximately walking speed. As a visitor's badge draws near to the display, one of the traveling particles stops and expands into a relevant article of information. The "braking" motion exhibited by the display subtly encourages a traveling visitor to pause for a moment and observe the display. As the visitor walks away, the article collapses again into a moving particle. These displays are designed to be eye-catching and to provide a teaser of a more complete information set to be viewed in the lobby.

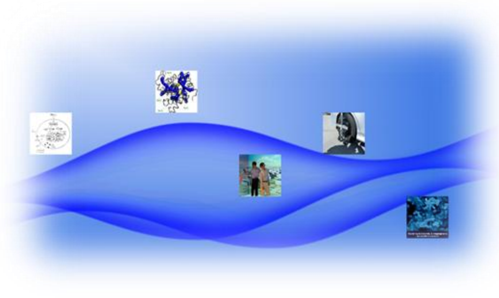

Figure 5: Particles traveling in the wave.

Lobbies

The lobby spaces, directly opposed to the quick foot traffic that will frequent the hallways, will routinely contain visitors waiting for appointments or meetings – allowing the lobby displays to present a more detailed information set. Waiting visitors will first see a field of particles similar to those traveling through the displays in the hallway space. Approaching and activating the display will trigger a particle to expand into a more detailed article, biography, photograph series, or similar complete set of information. The display is to be large enough that two people can simultaneously read two complete articles on the screen (one on each side of the display).

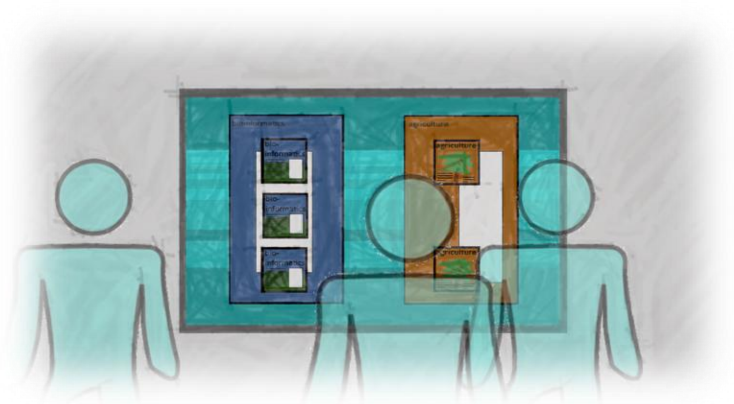

Figure 6: Screenshot of a simulation for multiple people using the display.

In our development, Team F consistently found that even after eliminating other barriers of usability in a dynamic display, the simple requirement of input was one of the largest barriers of all. Our hands-off design seeks to eliminate that barrier by requiring practically no input to activate – all that is required is the simple presence of a visitor. The benefits of this approach are twofold; the absence of any input peripherals beyond an RFID detector allows each of the displays, ideally, to be embedded into the walls of the lobbies and the hallways to become a real part of the fabric of the second floor, rather than an obvious outgrowth. In addition to this, a display which reacts simply to presence requires the absolute minimum of human input and therefore is the most approachable. A visitor who is presented a login screen, a keyboard, a motion sensor, or any other required input device is simultaneously presented with a barrier between themselves and the information system. The hands-off system has no such barrier; it is entirely an element of the lobbies and hallways, in the same way as the windows, walls, and floors.

Design

The implementation of our system begins with the RFID badges offered to each visitor before entering the second story. It will be necessary to keep enough RFID badges on hand to handle a peak load of visitors with a good number of spares. A visitor who does not want to carry a badge would not be pressured to do so, though he would not activate a display with his proximity.

Figure 7: The front end of the administrative application.

Any RFID badge handed out is associated with a unique ID integer, which is the only information carried by the badge. Every active ID number is stored in a small database at VTRC-A, along with its associated interest tags.

This small database, in addition to storing active visitor ID's and tags, will also contain the images and articles that can be presented on each of the four displays. Each image or article, in a manner similar to each active ID, will be stored along with an associated set of tags.

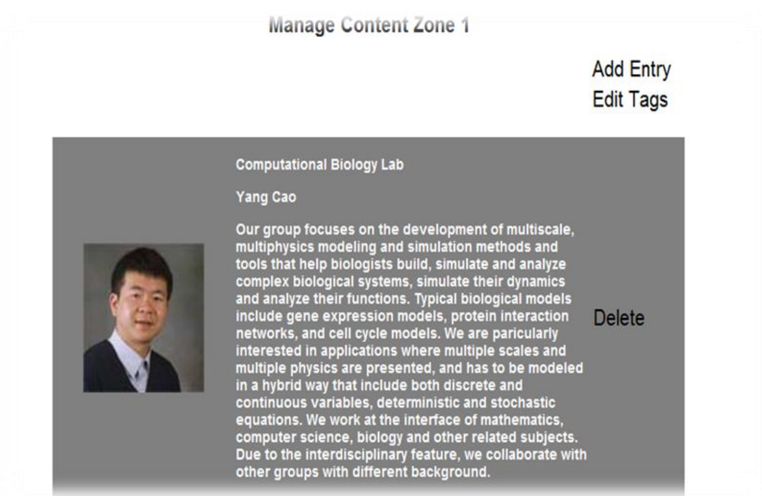

Figure 8: Adding content.

An activated RFID badge will allow any of the four displays to detect its presence by using an RFID locating device positioned out of sight behind each of the displays, ideally calibrated to activate only when a badge is within about eight feet from the display. The display's locator will relay the ID integer of the detected RFID badge to a small server. The server will retrieve the ID's associated tags from the database, then search the database for any images or articles which match the ID's tags – information which matches multiple tags is given priority over lesser matches.

Maintenance of the information presentable on the display, associated tags, and RFID's is accomplished through an administrative application accessible online. This web application allows new articles and images to be uploaded to the database, allowing the uploader to specify which displays will allow this information to be presented and which tags to associate with the desired information. This maintenance application will be accessible by a number of representatives from each department in VTRC-A, allowing all departments to represent their work and their workforce in the best way they see fit. A single receptionist in charge of distributing the RFID badges to visitors will also be given access to the administrative application in order to upload associated tags to an ID in the database.

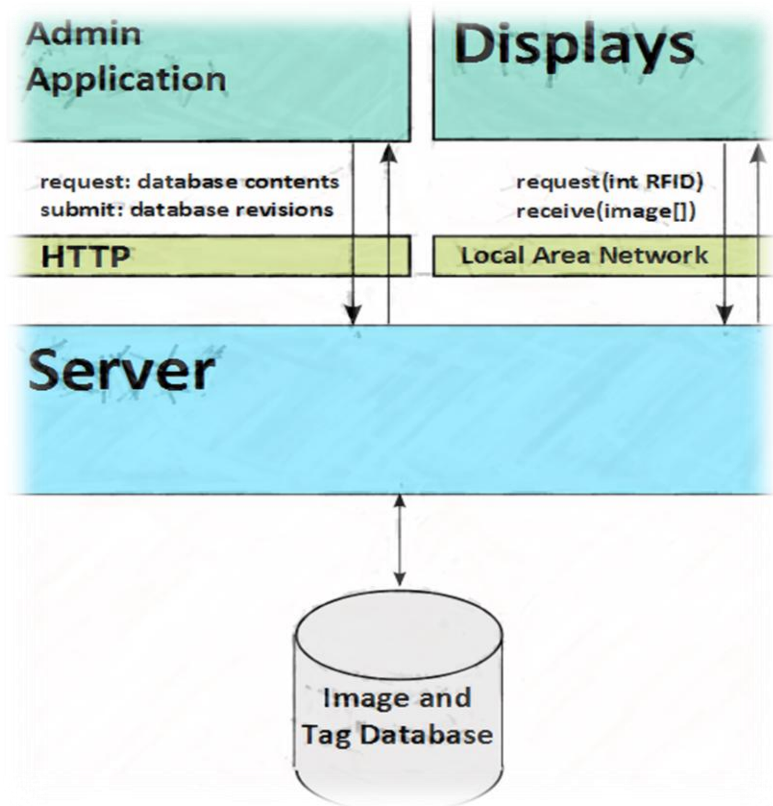

Figure 9: Infrastructure of system.

Upon leaving the research center, visitor badges will be re-collected in the reception area at the entrance to the center and cleared of their associated tags, allowing easy re-use of the badges. The entire system – from front-end to database – is straightforward and easy to maintain by virtually anyone in the research center, allowing longevity and ease of use.

Process

David Jacobs	Responsible for Overall Completion of Site, Content management and tagging.
Matthew Ryburn	Responsible for Gathering Content.
Weston Thayer	Responsible for Programming, programming final implementation of product.
Alex Vann	Responsible for Web Development, developing administrative interface webpage.

There are three main steps in implementing the final product and installing it at the site. The first is to prepare the dedicated server for uploading and maintaining the content for the site. This is done by creating two database tables for content and tags along with a third table that acts as a relationship manager between data in the first two tables. These three tables allow for users to upload data, create relationships between tags and content, and lookup a particular RFID chip's associated tags. After the tables are complete, the web interface is uploaded to the server. As it is written, the current web interface can be directly ported to another server as long as the database names in the webpage and on the server match up, so no significant changes need to be made to the current web interface.

The second step is to obtain and setup the displays. The displays need only fit the spaces and either take HDMI as input or standard formats. The VTCRA may choose to purchase Android devices with HDMI output or any computer for each display. It is also possible to have a central computer for all displays, assuming the hardware can handle the graphics requirements. The application need only be installed on the Android devices, where as the Android x86 Project will need to be installed on the computers. The existing software will run on either. The computing devices running the displays then need access to the intranet in the building, via WiFi or Ethernet. As long as these connections exist, the devices will work to query the database and populate the displays, all in real time.

The third step is to train the staff in the management and uploading of content. The actual act of managing and uploading content is very intuitive and can easily be taught through built-in tutorial that will be included on the website. In addition to the training of staff for management of content, there needs to be training provided for creating RFID tagged badges. In order for this to be possible an interface needs to be built to associate RFID numbers with particular metatags. This interface can be easily implemented with the current setup, only a webpage that interacts with the current database tables is needed. With these three steps, the process for creating the final site is complete.

Implementation

Our demonstrated implementation of the hands-free display system on December 6th used a prototype designed as an Android application using the Android SDK to demonstrate how our system's display would visually respond to a visitor. The system's administrative application was created using an interactive, fully functional website that allowed uploading of photos to the database, as well as editing of tags. Rather than personally investing in a RFID system, the demonstration approximated the reaction of the display using a Bluetooth connection with a pair of Android smartphones; 'discovering' one of the smartphones approximated the detection of proximity of an RFID.

The demonstrated version of the display showed a great deal of latency (around five to ten seconds) between approaching the display and the display's reaction, but this was largely a product of depending on Bluetooth technology rather than RFID – the polling frequency of a Bluetooth device is invariably low, many orders of magnitude lower than single purpose hardware like an RFID system.

This concession was made after discovering the price of an RFID scanner, which can run from $150 to over $500. Luckily, the technologies are very similar. The software would only require the implementation of an RFID object that supported scanning. Otherwise, the existing code will function.

For the displays, the flowing wave is available as an included feature of Android called Live Wallpapers. These utilize the graphics hardware on the devices for smooth playback using OpenGL. Photo animations are accomplished through Android's tweening framework.

The administrative website uses a combination of standard technologies. A SQL database is kept on the server, and is accessed in the HTML by embedded PHP. Links in the HTML call PHP to modify the document and the SQL database.

Greater Application

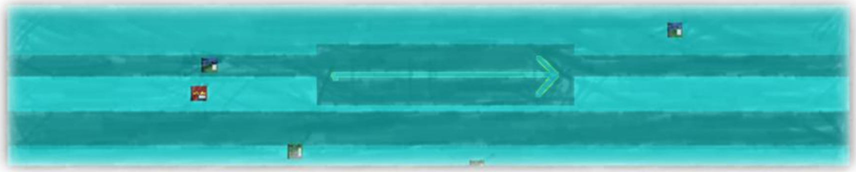

Figure 10: An early prototype supports direction.

The straightforward implementation of our system, as well as its easily generalized setup, allow its potential applications to extend far beyond VTRC-A. One of a handful of original concepts for the entire dynamic display system was a directions service; rather than providing visitors with information relevant to the research center itself, each display would react to a passing RFID badge by presenting a directional marker indicating the direction that person should travel to reach their destination inside the research center. While such a service would have served little purpose when only installed on the second floor of the facility, given additional space to set up such displays a mapping service for the entire building would be possible using exactly the same database, server, display, and RFID system.

The flexibility of our system is due in part to the ease of its scalability, allowing installations of practically any size (from a single-display installation to a building-wide network of displays) to be possible using the same setup. This allows the technology to be accessible to smaller installations, small businesses, outlet locations for larger groups, and other locations that lack the space or need for more than one or two displays. The system can easily be scaled up as well to support any number of displays distributed throughout a larger installation – for use as a site information display, as it was designed for VTRC-A, or for some other application like the mapping service mentioned before. This flexibility in size makes our hands-off system applicable and feasible in nearly any kind of interior.

Supplementing the system's scalability is its flexibility to be used for many more purposes beyond the one it is designed for at VTRC-A, just one of which is the mapping service mentioned before. This is due in large part to the generalization of the system's back-end, which can support any kind and any number of possible tags and images to display. These abstracted tags represent interest groups in the VTRC-A, but elsewhere they could represent destinations, the virtual contents of a shopping cart, a security access level, and more. Flexibility is also achieved by decoupling the server and database from the displays themselves, allowing the displays to use images sent to it by the server in any number of ways. In a broader application, the RFID badges as would be seen at the VTRC-A need not be badges at all, and could take any shape or be embedded in practically any object – this allows the system's possible applications to be nearly limitless.

In its current incarnation, the hands-free system is limited to presenting only images to a display; in the future, an evolved version of the system could serve URL's, documents, audio files, or practically anything else to a display.

Looking Back

Designing the hands-free system has allowed us a glimpse, however accelerated, of the deployment of a well-designed system, from its inception to a late prototypical stage. Most of the obstacles we found along the way were inadvertently placed there by ourselves at an early point in the development of our design; chief among them, discovering a way to implement a functioning prototype of our system using real RFID. While this was an obstacle we were able to sidestep to some degree (Bluetooth proved, as expected, much easier to wrap our heads around in a short period of time due to Android's APIs) other obstacles required us to have a clear understanding of our skill sets and our shortcomings, and to manage the project professionally and in a timely fashion.

First and foremost, development of the hands-free system taught us to be resourceful. In its earlier stages, the RFID system had every appearance of being very straightforward to prototype. A RFID scanner, however, is not available at every Radio Shack; and the implementation of a stable, efficient system based on RFID over the span of a few months using all the skills we had available would have proven to be incredibly time consuming, and possibly destined to fail. What this forced us to do was improvise; a brief study revealed the functional similarities between RFID and Bluetooth technology, and barring the latency issues experienced when building our prototype around Bluetooth, the approximation we achieved was quite successful. This improvisation demonstrated not only our team's resourcefulness and quick, innovative thinking, but also our ability to deliver a working product within a tight timeframe.

Our design also forced our team to be resourceful not only in the gathering of materials, but in the gathering of new skills. A total lack of any web design skill would have been a disaster approaching the end of the hands-free project; this forced the team to be able to quickly tackle and implement methods and languages with which we had previously only had a cursory experience, if any experience at all. This speaks highly of our team's eagerness and aptitude for approaching unexplored technology, and rapidly deploying it to great effect.

Finally, management of every group member's skill set was integral to the assembly of the hands-free system. Each team member came to the table with an entirely different set of tools; some with extensive experience in web design, some in the design of systems, and still others in over-arching visual design and unconventional human-computer interaction. Each stage of the project presented challenges daunting to some members and easily surmountable to others; our strength came from our capability to carefully distribute tasks among the members of our group.