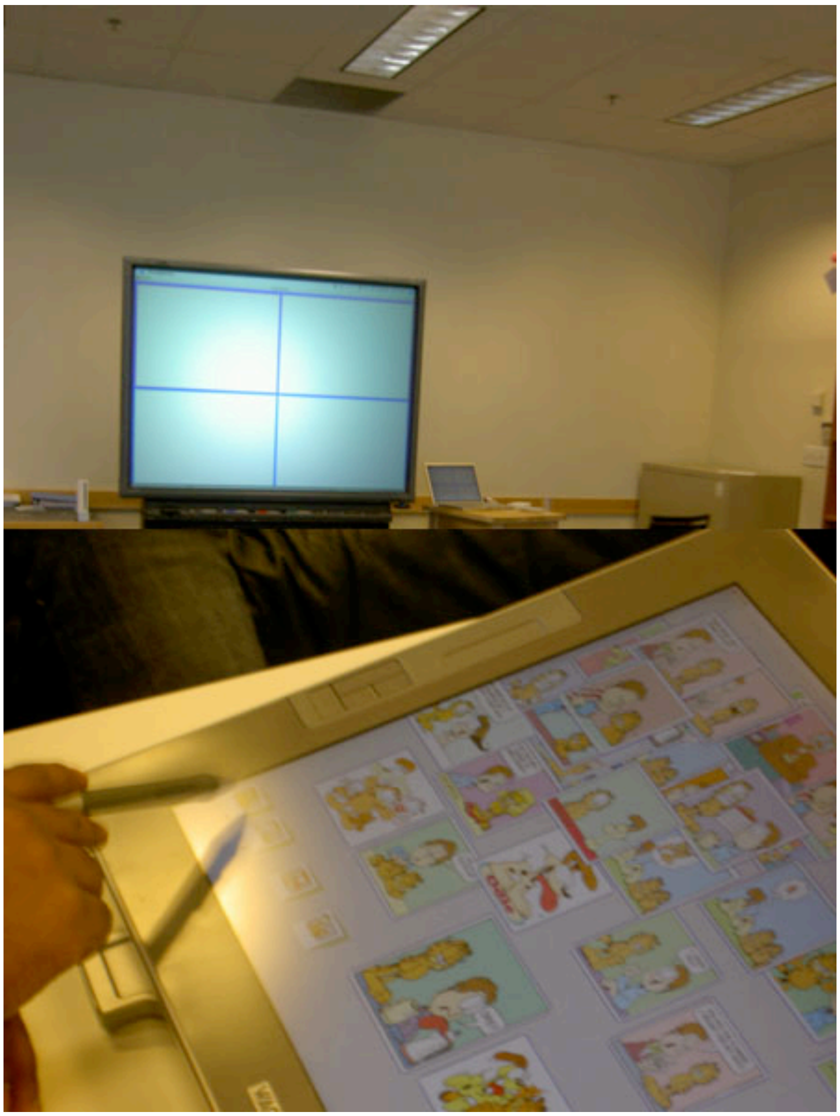
Interaction with digital surfaces



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Introduction:

In the recent decades, the advance in digital workspaces has been mainly focused on personal activities. Currently, users are primarily limited to individual work and display technologies such as laptops and PDAs; however, as tasks move onto computer-based technologies and become increasingly complex, the importance of supporting collaborative activity is becoming increasingly relevant. It is for this reason that considerable effort is being invested in understanding how large digital displays (including both horizontal and vertical displays) can support collaborative activity.

Horizontal workspaces or tabletops mimic physical tables, which have always been used for collaboration. These interactive tabletops may play an important role in the future collaborative work spaces, since they can offer the benefits of traditional tabletops (i.e. supporting pen and paper use) while concurrently supporting access and manipulation of digital files. Using these digital tabletops, users can orient the data files according to their seating orientation, and easily access and manipulate these files. Most importantly, these digital tabletops provide them with a space to share digital information in socially fluid and meaningful ways (i.e. re-orientating information), eliminating the awkwardness of "sharing" a traditional computer monitor.

Another digital surface frequently used to facilitate collaborative activities is a large vertical display—often used in concert with laptops and PDAs. This type of display is being used more in boardrooms and other collaborative environments to support presentations, and is proving to be very useful. The best way of interacting with these large screens how ever is still greatly unknown and is being vastly studied.

Our project was to design an interactive collaborative workspace that combined both a tabletop and large vertical display in a seamless manner. Such a workspace provides users with a fluid means of presenting and making sense of information such digital media: the tabletop would provide an excellent platform for manipulation, while the large vertical display would provide a platform for presentation.

Project Description:

Media and Graphics Interdisciplinary Centre (MAGIC)

The Media and Graphics Interdisciplinary Centre (MAGIC) was created at UBC to foster research covering the entire spectrum of new computer-based and computer-associated media. Some examples include multimedia, mobile computing, computer animation, 3-D modelling, interactive Web-based applications, hypermedia, computer music and computer-based tools for collaboration in education, medicine and entertainment.

The Centre highlights the commitment of UBC to the use of advanced media technology, and brings together existing efforts and new initiatives from various research programs. MAGIC serves as a catalyst to assimilate and exploit new technology in research and education at UBC and to strengthen interaction with industry through collaborative research.

Related Project at MAGIC

MAGIC has developed a prototype Family Blog application that explores the use of smart phones to capture media, and large home displays to allow users to collaboratively create a Family Blog. Their current version of the application not only uses Smart Phones to allow users to capture multimedia artefacts (pictures, video, audio), but also to upload these artefacts to a large screen display application, and to control the application using the Smart Phones.

MAGIC now wishes to compare the cell phone interaction model with a tablet/tabletop interaction based on simple gestures.

Project Goals

The goal of this project was to create a collaborative work space using an interactive tabletop and a large screen that eases control and manipulation of digital data files such as photos and enables the sharing and displaying these files using the larger vertical display. These digital files would be uploaded from other devices such as smart-phones to a tabletop.

The tabletop display is connected to a *large vertical display*. The large vertical display is used to present the files/multimedia artefacts in a larger scale (e.g. full screen) and with media artefacts associated with individual users. Users can now use *gesture* interaction to drag and drop (or ‘flick’) icons from the tabletop towards the large display where they are presented.

The main goals of this investigation are:

- If users understand the setting of the different display types and if they appreciate such a set up.
- A comparative analysis of tabletop gesture versus smart phone interaction.

As mentioned above, a similar set up has been done with smart phones and large displays for the Panasonic project and could be used for the comparative analysis as well as for code reuse. The result will allow us to a certain level to get an answer to the question if a set up of *tabletop – large display* is a reasonable scenario for home applications.

Development tasks:

- Design an application that provides a shared workspace by integrating the tabletop and the large screen.
- Design and build the server client communication between the tabletop and the large screen.
- Design a gesture based application that uses intuitive gestures for the user and gives a feedback that mirrors the real world situation.
- Create a support for gesture recognition.
- Integrate with server side large screen application
- Design user study
- Run user study and improve product on feed back

Technical issues:

- The main structure of the system will be programmed in Java.

Management:

Tony Tang will have primary responsibility for the project and will act as day-to-day interface for the design and development issues. Matt Finke will provide support as needed.

Research & Related Work

Before we can discuss our contribution we need to understand the state of the art in the field. In this chapter we will converse the current trends within relative user interfaces.

In the first sections we will look at interactive tabletops, next we will discuss how Large Screens are currently used. In the third section we will look at how these two surfaces can be integrated to … collaborative workspace.

Collaborative workspaces

Collaborative workspaces have been subject to research for many years. Many systems have been proposed and created that have enabled the users to carry out cooperative interaction with digital files and artefacts. As mentioned before digital surfaces are a very convenient and user-friendly way of facilitating these activities.

In real life we use surfaces such as tabletops to share and discuss data, we use white/black boards to present and display our ideas to a group of people and still allow other users to manipulate this data. Therefore using similar surfaces can help us create a virtual collaborative user interface.

Interactive Table Tops

Interactive virtual tabletops offer great support for many collaborative activities; they can be used to ease cooperative designing, mind mapping, story telling, group decision-making and many other applications with an emphasis on creative processes. These horizontal interactive displays are being used more frequently in the recent years, despite all the research involving these displays they still have limitations that are inconvenient for use. One of these limitations is lack of control, objects can be across the table form the user and therefore hard to reach.

Geißler [1] introduced a "throwing" gesture that enables interface items to smoothly slide across larger distances. However, this throwing gesture tends to be too inaccurate for some tabletop activities, such as moving an item to a specific location across on the display [9]. Two boundaries (see Figure 1(b)). REFRENCE **Evaluating the Effects of Fluid Interface Components on Tabletop Collaboration**

Another problem concerning these tabletops is the issue of visibility; the data or artefacts are displayed on the tabletop in a size that is appropriate for personal viewing and not for group viewing. These items are small and more importantly their orientation is only appropriate for the person sitting in from of them. Collaborative activities such as decision making are most convenient when the group are sitting around the table on opposite sides of each other so that they can discuss ideas face-to-face, the data file however is positioned in front of one person and the rest of the team have different viewing angel and therefore can have different perceptions of the data file or artefact.

Vertical Large Screens

Vertical Large Screens are very convenient to use for displaying data for a group. They solve the visibility problem and display the files or artefacts clearly. These large screens can be easily integrated into homes and offices and facilitate individual and collaborative activities.

These screens are now largely being to display the data coming from an individual computer. This limits the possibility of using a large Screen where different regions can be accessed and used by different users.

Integrated possibilities/solutions

Since these large Screens are growing continuously bigger, using this large display space is a hot topic of research. The future of these screens demands that they would be used for more than just displaying media and instead be used as interactive display tools accessed by multiple users.

Different ways of interacting with these screens is now being vastly explored,

And these screens are now being used more frequently in combination with multiple personal work spaces such as laptops to create a shared display environment for multiple computers. The ' Mighty Mouse' tool for example introduces an approach, for face-to-face collaboration, in which multiple heterogeneous computers (usually laptops) are viewed simultaneously (usually via projectors) by people working together using a variety of applications running on various platforms implementation of the VNC protocol [1], the ability to control multiple heterogeneous controllers in sequence which builds on the previous work of VNC REFRENCE MIGHY MOUSE.

Such approaches how ever limit the users to computers that are designed for individual activities as an interaction medium with the shared display environment and can cause many challenges and confusions for the users for example at times of simultaneous manipulation of data and also only having access to only their own personal data on the

Large screen.

Integrated solution:

Despite all the research in both areas of digital table tops as collaborative work spaces and Large Screen as shared display environments, very little is know about how these tools can be integrated to create a more convenient collaborative environment where digital data and artefacts can be easily accessed and manipulated using the table top and clearly displayed using the Large screen.
Integrating these two digital surfaces can eliminate the limitations that are caused by the digital tabletop such as view ability, since all the involved parties will be viewing the same Large screen in the same orientation and size. Integrating the tabletop with the large screen also solves the problems cause by using only the Large screen where all parties involved can directly access and manipulate the Large screens using the tabletop which is itself designed for multiple users and cooperative activities. In this way the Large Screen is used as a shared display tool that will help the team view the ideas and artefacts that are created/ altered and discussed on the digital tabletop. Such an application would be of great use in many areas where collaborative brainstorming, decision-making, designing, browsing, story telling and many more applications are involved.

Requirements:

Functional requirements

The user must be able to execute the following actions;

- Move photos around on the virtual tabletop
- Rescale photos
- Delete the unwanted photos form the tabletop permanently.
- View a collection of photos
- Remove (a collection of) photos from the tabletop temporarily.
- Move photo stacks around on the virtual tabletop
- Making a new collection of photos in the form of a stack and organising the existing photos into piles.
- Accessing the Large screen, and manipulating its content using an interactive medium.
- Adding pictures to the Large Screen using an interactive medium.
- Removing pictures from the Large Screen using an interactive medium.
- Displaying multiple pictures on the Large screen by means of slides show or an arrangement of multiple photos on the Large Screen.

Non-functional requirements

`User interface:

- The application must be easy to use and the functions must be intuitive.
- The user must receive feed back after executing an action (both on explicit and explicit actions).
- The Interface must reflect the users mental model.
- The user must be able to directly manipulate all the elements on the virtual tabletop.
- The user must have control over the object that is being manipulated.
- The interface must appear stable and attractive.
- The interface must simulate the real life situation.
- All Interface elements must be clear to the user.
- The users must be able to access the photos independent of their location around the tabletop.
- The users must be able to view the photos on the Large Screen with the same viewing angel.

Performance:

- The system must be suitable for a real time application. The artefacts must appear on the large screen at immediately after they have been placed there by the user and they should be removed in real time.

- The correct artefacts must be displayed on the Large screen.

- If there's a visual feed back of the large screen on the tabletop, it must be consistent with what is being viewed on the Large screen.

System extendibility:

The system must be built in away that allows fort future extensions to the interface by other developers.

System

- The application must be ran on a tablet.

General Design

The Main goal of this project was to design and implement an application that integrates a horizontal digital surface with a Large Display. This application must help us understand the advantages of using an interactive horizontal surface as a collaborative workspace, and explore the benefits of combining this surface with large displays.

Therefore we explored several possibilities that represent cooperative activities involving digital files. We researched which activities could be greatly improved by integrating an interactive digital tabletop and a large display. We narrowed our options down to 5 different categories each representing a an area where collaborative activities can be greatly improved. 1. Photo Editing, 2.Interior design tool, 3. Comic book design tool, 4. Mind mapping and project management tool, 5. Photo Sharing(in the form of a family b-log) .

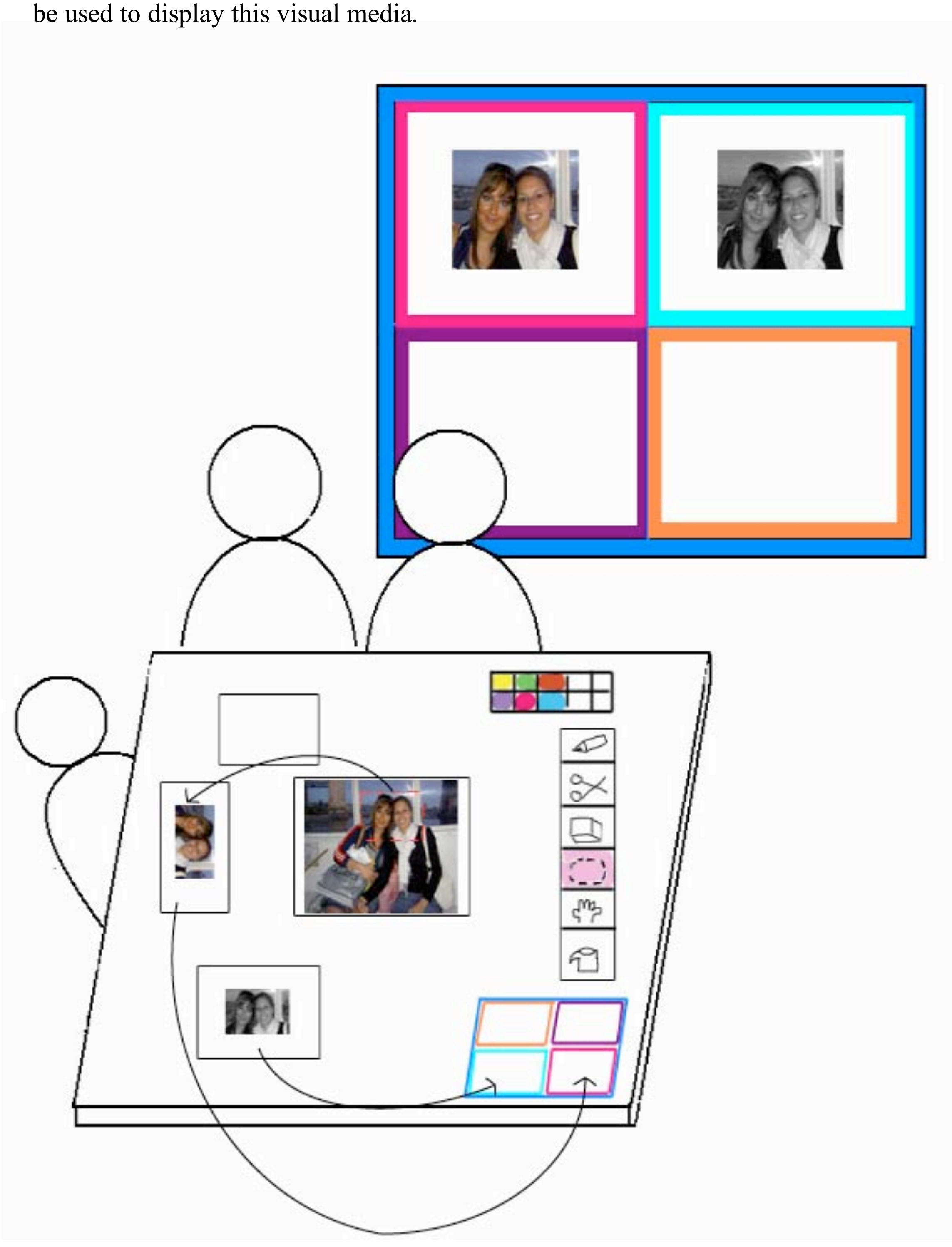
We looked at the existing applications in these categories and studied how they can be improved using a tabletop and a large display, and came up with initial design concepts for each category. In order to improve our designs and selecting the best concept we tried to user test the designs by asking a few test users to pretend to be using the application using for example photos on a table. We also tried to do this ourselves to get a feeling of what the users want and we researched further. Finally we came up with the final storyboards the 5 categories.

In the next section these categories are shortly discussed, and the selected concept will be represented.

Photo Editing

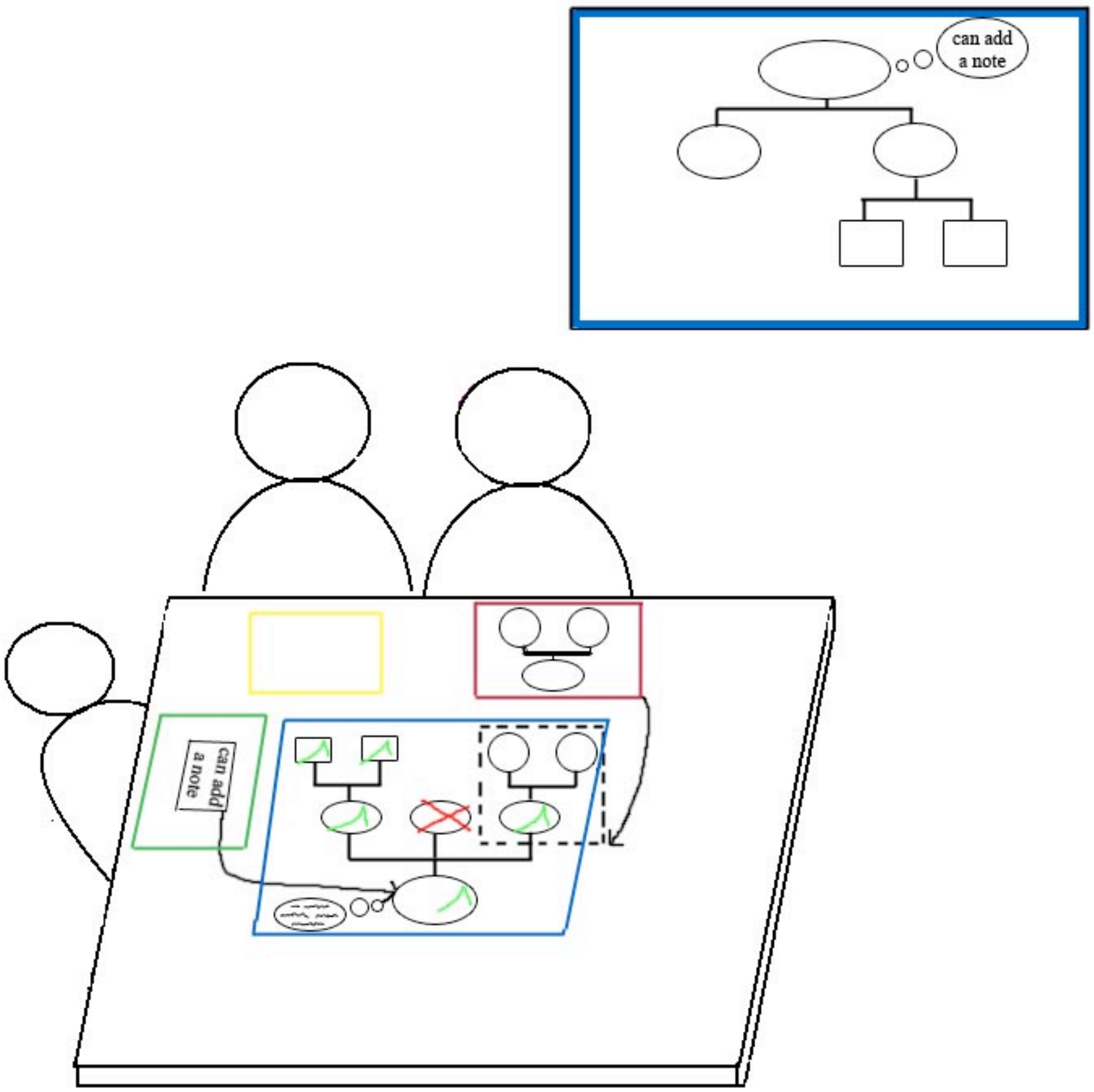
Photo editing has been around as long as photos have been around. Before computers, photo editing was done by retouching with ink, paint, double-exposure, piecing photos or negatives together in the darkroom or scratching Polaroids.

Digitising photos has made this application easy and convenient. Editing photos is used for many purposes today. But the existing applications mostly allow only individual interaction with the photos and do not provide tools for collaborative work. An interactive tabletop can be used to support this kind of group editing and large screen can be used to display this visual media.



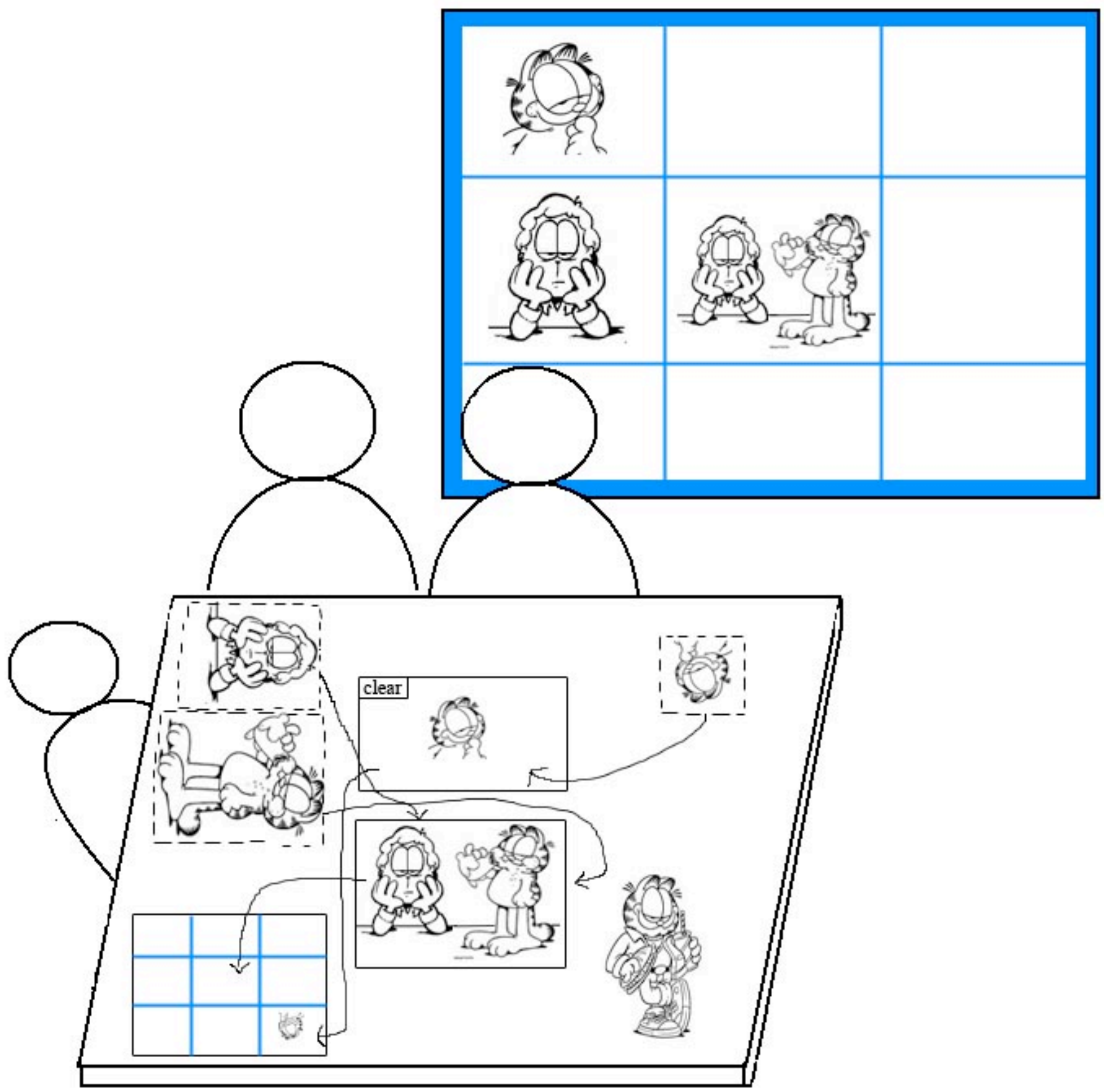
Mind mapping and project management tool

Collaborative decision-making is already benefiting the use of large displays combined with several individual computers. The existing applications raise the issue of control where the users only have access to their data on the large display and cannot manipulate the data as a hole. It also causes distractions as users all have separate individual workspaces, which is not appropriate for such collaborative activities. Studying the use of an application that allows user to work together on the same data on a tabletop combined with large displays that are already used in the industry can have many benefits and can greatly ease the process of collaborative decision making.



Comic book design tool

Collaborative design and story telling were mentioned earlier on in the report as two of the tasks that are in demand of digital collaborative work spaces and shared displays and are therefore a good candidate for our application.

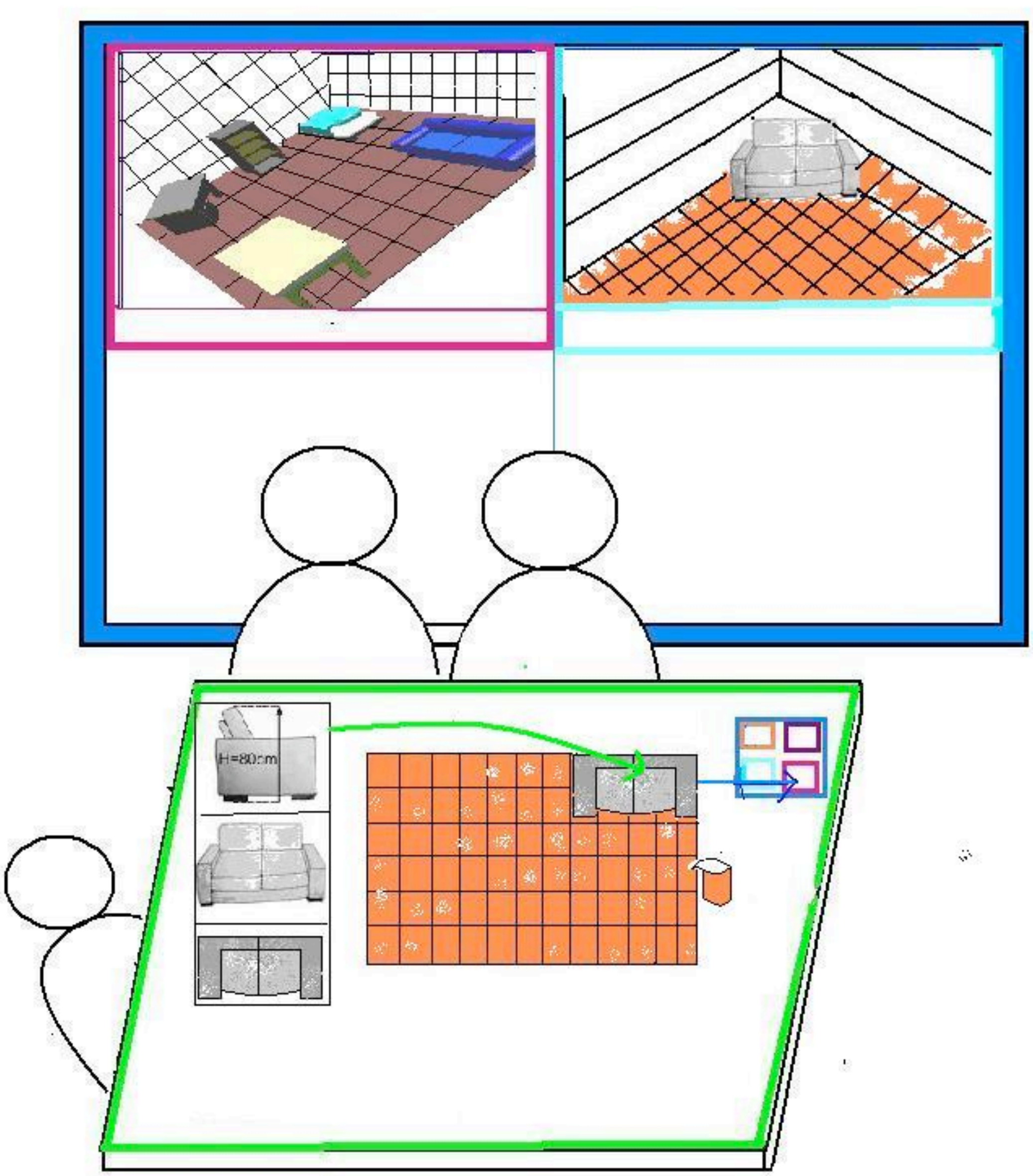


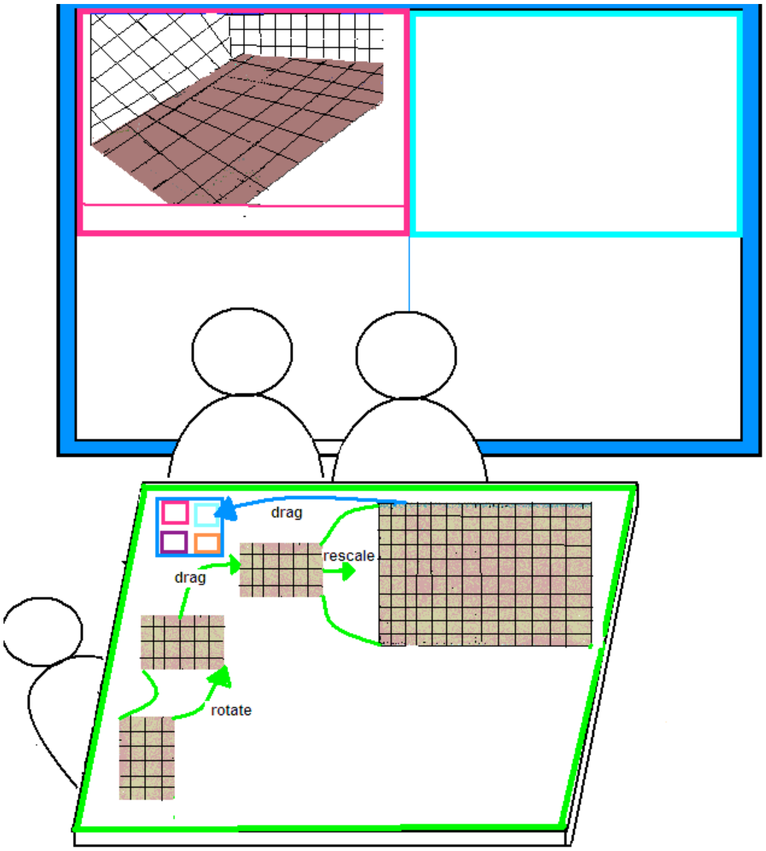
Interior design tool

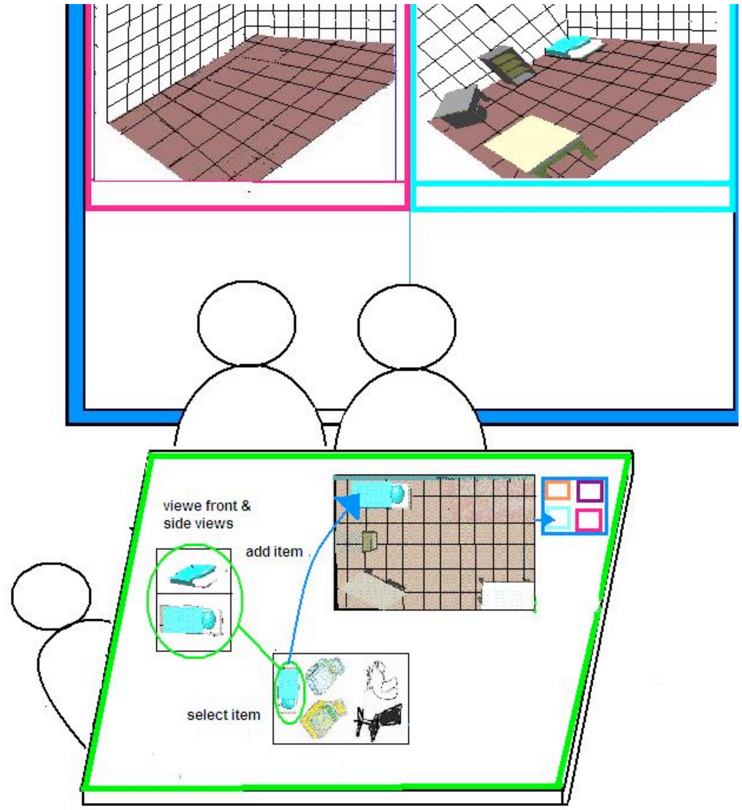
Collaborative designing is a perfect example of a cooperative activity that is in need of a computational application that eases the process of design and collaboration.

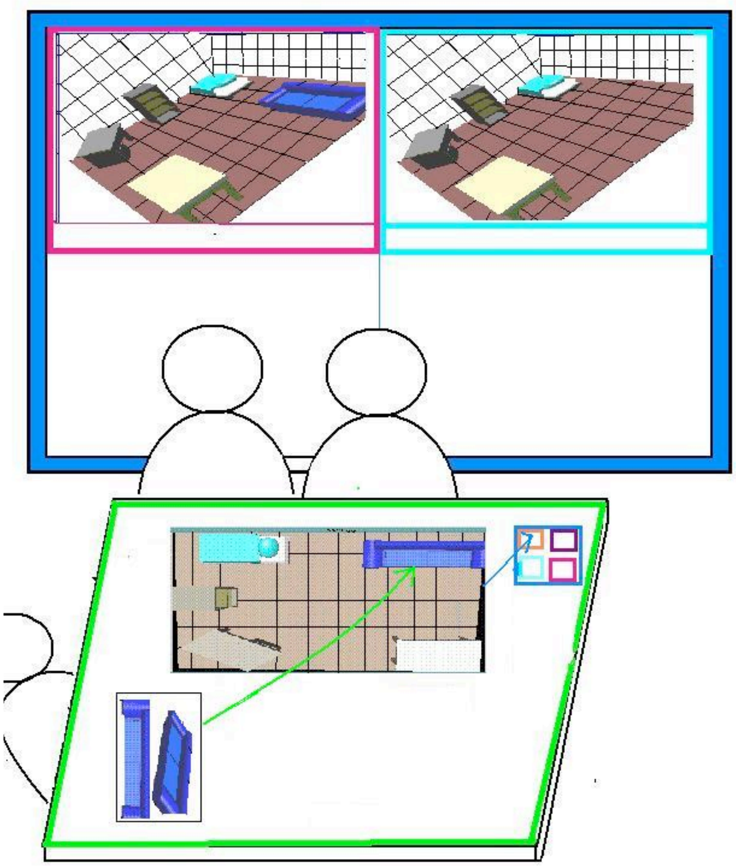
As interior design is growing more popular, more and more digital applications are created to help the designers.

Therefore an application that uses a collaborative workspace for the design part and a large screen for the display and sharing part can greatly help this trade.




drag
drag
rescale
rotate


viewe front &
side views
add item
select item



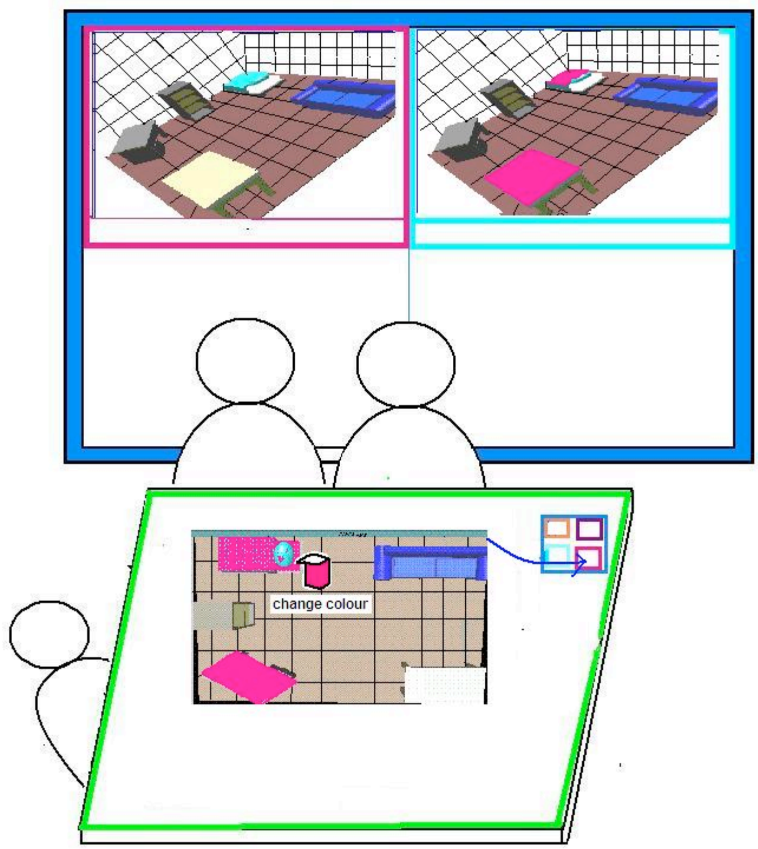
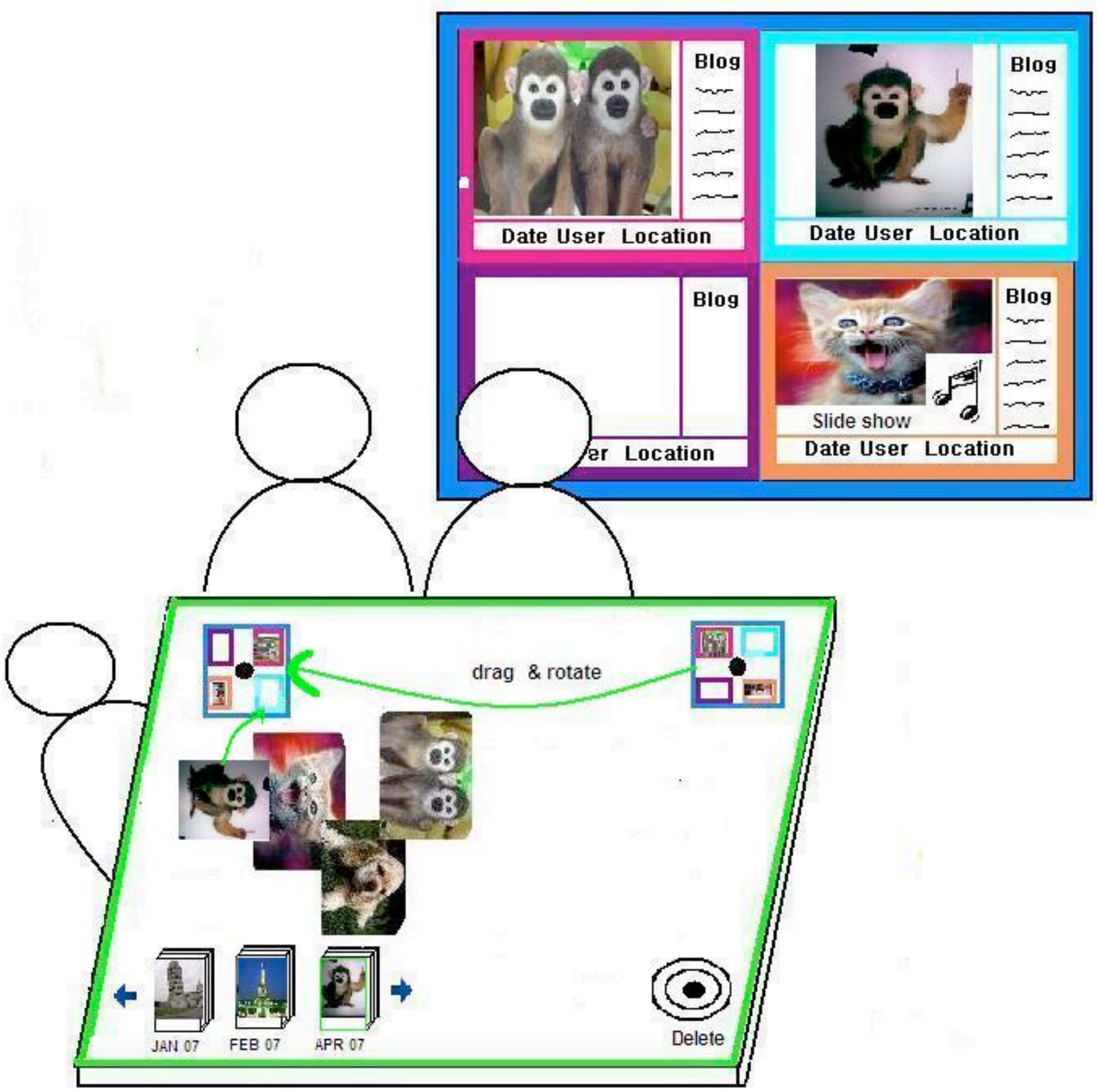

change colour

Photo Sharing (Family blog):

As digital cameras made their way into markets and into every household and cell phones integrated these digital cameras, photos have become a digital media.

Digital photos are a perfect example of digital files that need to be shared and displayed within groups of people and therefore are perfect representatives of the type of digital files that we need to explore in our study.

As photos are visual media, technology is continuously creating new ways of displaying them. Viewing photos on large displays greatly helps the visibility of details and allows a big group to view one picture clearly and with the same viewing angel.



After discussing all the candidate applications and studying the storyboards we decided to use the 5th category; Photo Sharing for the following reasons.

As mentioned before photos are visual media and using a large display to augment this media improves the shared understanding of the context and is more attractive for the users. It gives the users a more detailed view of the pictures and allows a group of users to view the pictures with the same perception, size and viewing angle. Therefore using a large screen as a shared display tool will solve the visibility-issues that exist in the current applications and provide a great improvement.

People view, browse through and share pictures everyday sitting around their coffee table showing them to each other rearranging their photo albums and discussing the pictures. Hence using a table as a metaphor would suit our application perfectly where we use the digital horizontal surface to replicate a tabletop. Using an interactive digital tabletop will allow them to interact with the pictures and move, rearrange and manipulate them as they wish.

Combining our digital surfaces will allow the users to interact with the pictures freely in a collaborative workspace before viewing them on the shared display while giving all users access and control to what is being displayed.

Another reason why we chose to build this application was the prior work that was done in the MAGIC lab on creating a family b-log using a smart phone as interaction tools with the Large Screen. Creating our application in the same area will help answer questions about the best way of interacting with large displays and will help find whether users prefer to interact with individual workspace to interact with the large display or a collaborative workspace.

Prototype1:

After choosing the area in which the digital surfaces would be integrated, the first prototype of the application was designed and built. The process of building the first prototype will be discussed in the following section.

Design:

User interface Design:

Many issues were discussed and taken into consideration before designing the first prototype. The fist step towards designing our application was to look at the requirements and insure that our product will fulfil all of them. The most important part of the study however was to build a system with an intuitive user-interface that fits the users mental model and is very easy to use and provides optimum interaction elements.

In this section the first steps of the design process will be discussed and the general design choices will be layed out. Next the different features and elements that were designed will be explained. Finally some of the different scenarios corresponding to the possible functions in the system and their matching concept drawings will be presented.

Initial design concepts:

The following design represents an intuitive application where users can sit around the table lay their pictures out on the table top, sort and organise them using stacks of photos and move them around freely on the tabletop.

All the different elements that are placed on the tabletop were designed to be independent. All elements can be freely moved around the tabletop.

Studies show that the visual notion of colour help users distinguish between different elements and regions. Hence the different elements were mostly assigned different colours, while the colour blue was still maintained in many of the elements to hold the consistency of the system as whole.
All elements were designed to have the same general rectangular shape, and can be distinguished with the different sizes, labels, icons, and colours. This was done to serve the notion of consistency and still discriminate between the different elements.
All these tools were designed to visualise the mental model of the users either by simulating real life objects/ actions or by replicating standard desktop features. Making the actions intuitive provides ease of use.

These elements will be discussed in more detail in the later sections.

The Large display was designed to have a pre-defined structure with four different regions each intended to be used by a different user.
This design was chose for the first prototype to examine the advantages and the disadvantages of such a framework which prevents clutter on the Large display and makes optimum use of the whole screen.

The multiple user panels were designed to allow different users to display photos on the Large Screen simultaneously. However a full-screen function was also designed to allow maximum augmentation.

As mentioned, studies have shown that assigning different regions of a work/display space helps the users distinguish between them. Therefore each of these user 'panels' was assigned a different colour.

A tool called the Teleporter-Pad was designed for the purpose of communicating and interacting with the Large Display. The users can interact directly with the Large display through this tool.
The structure of this element was designed based on a few fundamental factors. The basic structure was designed to replicate the structure of the Large display.
The TP is split into four different regions. Each region corresponds to a user-panel on the Large display and carries the same coloured border.
This helps the users relate the regions of the TP to the corresponding regions on the Large screen, regardless of their viewing angles.
The panels on the TP however were designed to be separate with some space between them. This space must be made translucent in order to give more visibility to the user; when the TP is dragged around on the tabletop the user can still view what is underneath it.

To give the users a sense of connectivity and provide direct access to the Large Display, the Teleporter-Pad was designed to give a clear visual feed back of the events on the Large display. The user can view at all times what is being displayed on the Large Screen and on which region.
By adding and removing photos to the different panels of the TP this photos will appear on (or disappear from) the corresponding panel on Large Display.
The Teleporter-Pad will be discussed further in the next section.

Another one of the basic features that was designed was the concept of photo stacks. These stacks were designed to represent a collection of pictures that are either input to the system by the user, or are made of existing pictures on the tabletop. This notion helps users share photos and avoid clutter on the tabletop, and keep or display a collection of context related data together.

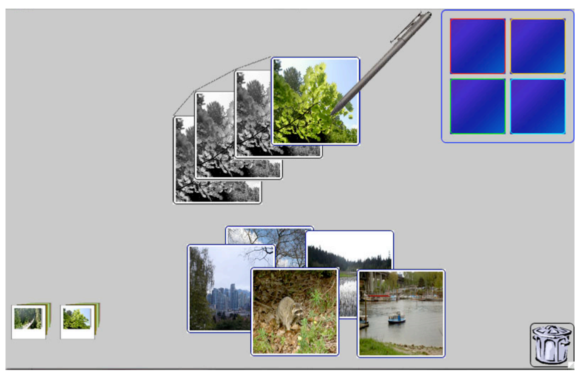
To inform the user of all the events on the tabletop and give and help them envision the outcomes of their actions on the tabletop, all the features were designed to give visual feedback to the user. This visual feedback is often in the form of a highlighted border, which matches the colour of the tool that the user is interacting with. This helps the user relate the action to the corresponding tool and understand its meaning. The visual feedback corresponding to each element will be explained later on in this chapter.

Individual Design Choices:

The individual design choices were made to full fill the requirements that were discussed in the last section. In these design choices will be explained in this section.
Each individual tool/ feature of the system is demonstrated in a separate table, were the corresponding requirement is shown.
While designing each of the elements 2 main issues were considered: Ease of Use and Visual feedback. As discussed above these are the main factors that help us build a user friendly, seamless and ubiquitous system.

1.

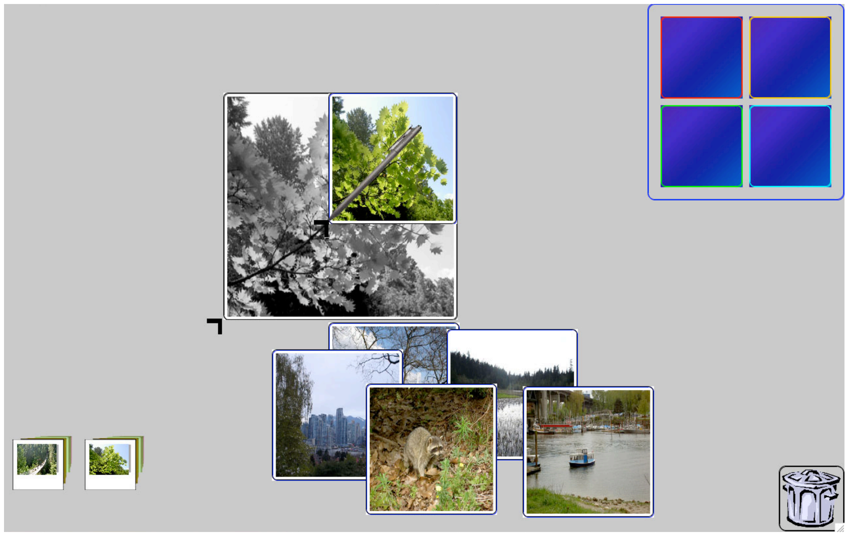
Feature	Requirement
A **drag** function that allows the user to drag the photos around on the digital tabletop using the input device.	Move photos around on the virtual tabletop



Ease of Use: This function is intuitive, the user slide the photos around on the tabletop just like they would real photos on a real table, using a pen instead of their fingers. This function is very clear and causes no distractions. Visual Feedback: users can clearly see the pictures moving around on the tabletop as if they were real objects being dragged around.

2.

Feature	Requirement
Providing **dynamic size** for the pictures so that users can rescale them in 8 different directions.	Rescale photos



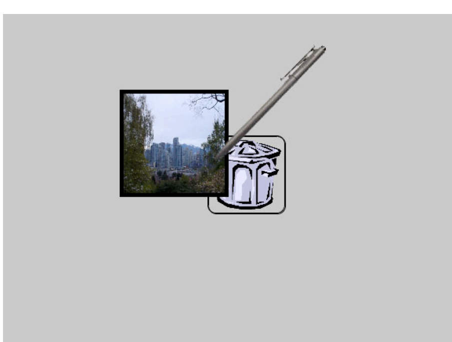
Ease of Use: This function replicates the standard desktop function. The users can rescale the pictures in 8 different directions by grabbing one of the 4 corners or sides.

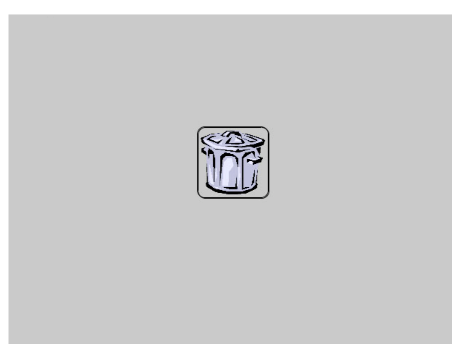
Visual Feedback: The application gives the user visual feed back by displaying the appropriate cursors when the user is pointing at one of the corners or sides of the picture(there are 8 desktop cursors that are familiar to the user corresponding to the 8 different directions).

The user can clearly see when this action can be executed and 'grabs' the corner of the picture, pulls it out or in and rescales the pictures as desired.

3.

Feature	Requirement
Trash element	Delete the unwanted photos form the tabletop permanently.





This function was designed in order to avoid clutter on the tabletop and allow the users to delete the pictures that are not needed/ wanted. The delete action is executed when the user places a picture on the trash element.

Ease of Use: This function replicates the standard desktop function. It carry a trash icon to let the users know that pictures will be deleted if dragged on this element.

Visual Feedback: The users can clearly see when a picture is dragged on the trash element since the picture gets a thick black highlight when it is placed in this area. The black highlight is removed if the user doesn't place the picture on the trashcan element but drags it back off.

4.

Feature	Requirement
A **stack** element where a collection of photos are 'placed' in a stack and can be viewed at once when the user clicks on the stack icon.	View a collection of photos

Ease of Use: this function is similar to standard desktop functions where 'clicking' on a file opens it and displays the elements inside. In this case the user presses on the stack icon and it's contents (pictures) spreads out on the table.

Visual Feedback: The stack icon that is located in the row of stacks carries the first pictures from the collection of photos in the stack. The user can see the picture and realise which stack they are dealing with. When the stack is pressed the user sees all the pictures appear on the tabletop.

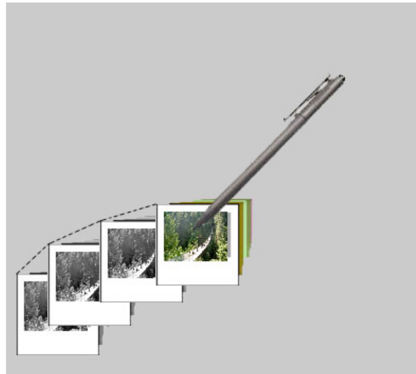
5.

<table>
<tr><td>Feature</td><td>Requirement</td></tr>
<tr><td>Close stack function; a second click on the stack icon removes the photos that belong to the stack from the tabletop and ‘places’ them into the stack.</td><td>Remove (a collection of) photos from the tabletop temporarily.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Ease of Use: this function is similar to standard desktop functions where a second ‘click’ on a file closes it. In this case the user presses on the stack icon a second time and its contents are removed from the table and appear to be piled up back into the stack.

Visual Feedback: The user clearly sees that when the stack is pressed all the pictures that belong to it disappear from the table and therefore are piled back up into the stack.</td></tr>
</table>

6.

<table>
<tr><td>Feature</td><td>Requirement</td></tr>
<tr><td>A ‘dragstack’ function that allows the user to drag the photo stacks around on the digital tabletop using the Input device.</td><td>Move photo stacks around on the virtual tabletop</td></tr>
<tr><td colspan="2"></td></tr>
</table>

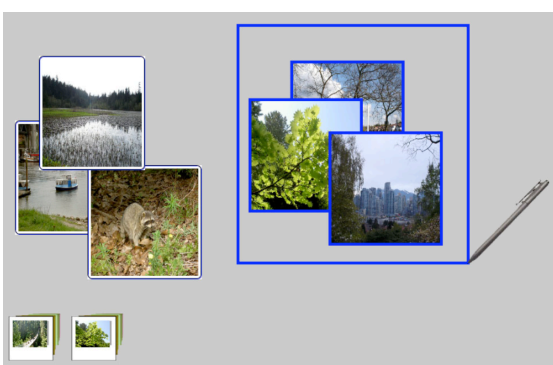


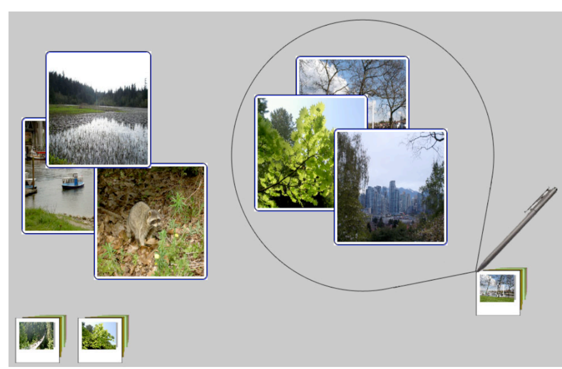
Ease of Use: This function is intuitive, the user slide the stacks around on the tabletop just like they would real objects on a real table, using a pen instead of their fingers. This function is very clear and causes no distractions.

Visual Feedback: users can clearly see the stacks moving around on the tabletop as if they were real objects being dragged around.

7.

Feature	Requirement
A selection tool to select the desired pictures and create a new stack from these pictures.	Making a new collection of photos in the form of a stack and organising the existing photos into piles.





Ease of Use: the selection function replicates the standard desktop functions where as the user clicks on the desktop and pulls the mouse in a direction a highlighted rectangle appears on the desktop and is extended as the user pulls.

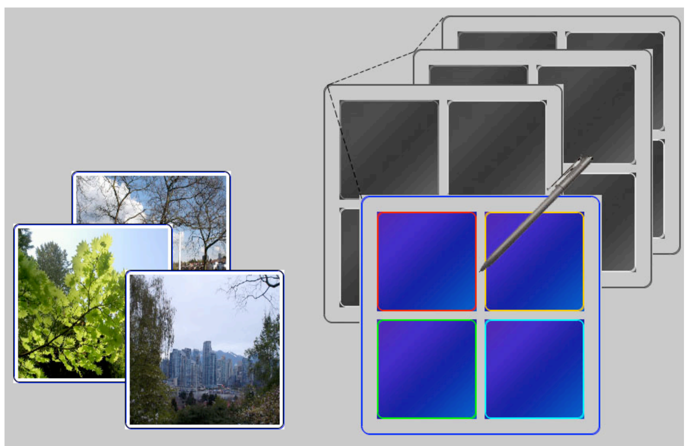
In this case as the user presses the pen on the desktop a blue highlighted rectangle appears on the desktop and all the photos that are located within that rectangle are highlighted, when the user releases the selected photos are placed into a new stack.

Visual feedback: The selection rectangle gives the user a familiar visual feedback, the

user sees that all the pictures that are located in the rectangle are highlighted as they move the pen around and therefore clearly see which photos are being selected and which not. The photos and the selection rectangle both have the colour blue, which helps the user relate the elements together and realise that they belong to the same function.
As the user releases the selection rectangle all the highlights are removed and a stack icon is added to the row of stacks, in this way the user sees that he/she ahs created a new stack of pictures using the selected pictures.

8.

Feature	Requirement
An interaction tool that allows the users to interact with the Large Screen. This tool is called the Teleporter-Pad.	Accessing the Large screen, and manipulating its content using an interactive medium.



In order to enable the users to interact with the Large display, an interaction tool was designed. This element is called the Teleporter-Pad and has the square shape of the Large screen. The structure of this element replicates that of the Large display; there are four squared regions each having a different colour borders. Each of these regions corresponds to a user area. As discussed in the last section each user region (panel) is given a different colour. This helps the users associate each of the panels to the corresponding region on the Large display (e.g. pink region on the TP corresponds to the pink region on the Large Display).

Ease of Use: This element can be dragged around to allow all users to access it regardless of their position around the table.

Visual Feedback: The Teleporter-Pad was designed to give a visual feed back of the large display to the user. The user can see at all times what is being displayed on which region of the Large screen. This will be discussed later. All the actions executed while interacting with the TP are confirmed to the user by visual feedback (this will be discussed in the following elements).

9.

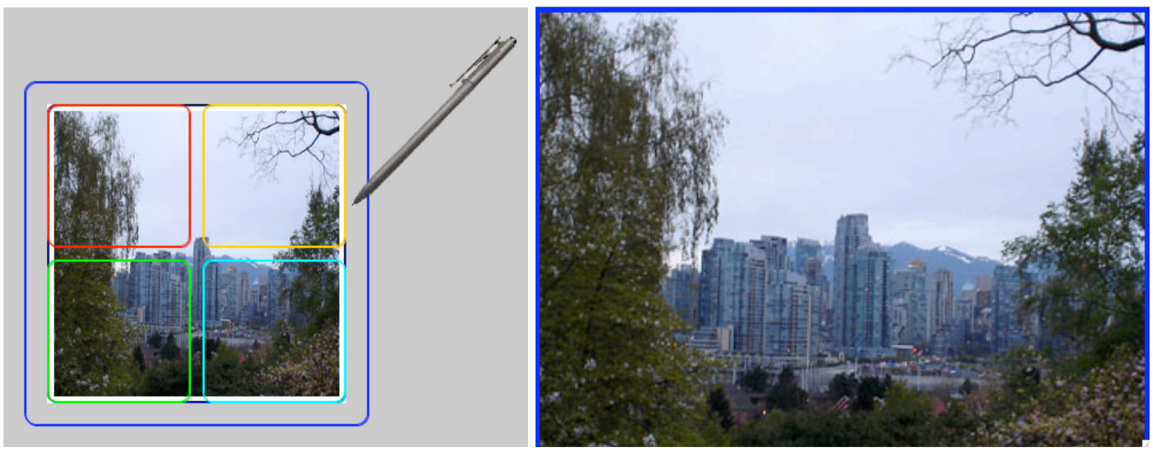
Feature	Requirement
An add function where the user drops a picture on one of the user panels located on the Teleporter-Pad(TP). The picture will appear on the Large display immediately.	Adding pictures to the Large screen using an interactive medium.

Ease of Use: This function is very intuitive the user grabs the photo and drags it on top of the TP. When the user 'places' the photo on one of the user panels the picture is added to that user panel and the same picture appears immediately on the Large Screen.

Visual Feedback: The visual feed back in this function was designed to let the user know (i) when a picture is dragged on top of the TP on one of the panels ;the picture transforms into an icon which is a smaller version of the picture (the size of the user panel on TP). The icon becomes highlighted with the same colour as the corresponding user panel. In this way the user can relate the two elements to each other and foresee that if the picture is placed in that location it will be added to the corresponding user panel.

(ii) Let the user know the picture is added to one of the user panels and will appear on LS. When the picture is 'dropped' one if the user panels it is 'added' to it.

10

Feature	Requirement
A full-screen feature where the user drags the TP on a picture and views the picture full screen on the large screen.	Adding pictures to the Large screen using an interactive medium.
	
Ease of Use: This function is similar to feature 9. In this case the user drags the TP on top of a picture. When the TP is placed on the picture, the picture will appear full-screen on the TP and on the Large screen. Visual Feedback: When the TP is dragged on the picture the pictures is highlighted with the same blue colour as the background of the TP. This lets the user know that if TP is placed on the picture it will be added to it. When this happens the picture covers the whole TP area to show that the picture is being displayed full-screen on the Large display.	

11.

Feature	Requirement
A remove function where the user drags a picture off the TP. The corresponding photo on the Large display will be removed.	removing pictures from the Large screen using an interactive medium.

Ease of Use: This function is very intuitive and resembles the real life action of slide an object off of an area. When the user slides the picture off the TP it is removed form the TP and the Large Screen.

Visual Feedback: When the picture is dragged off the TP the highlight is removed and the size of the picture turns back to what it was prior to the addition. The user clearly sees that the picture is being dragged off the TP and onto the tabletop. The icon is removed from the TP and the corresponding picture is removed from the Large Display.

12.

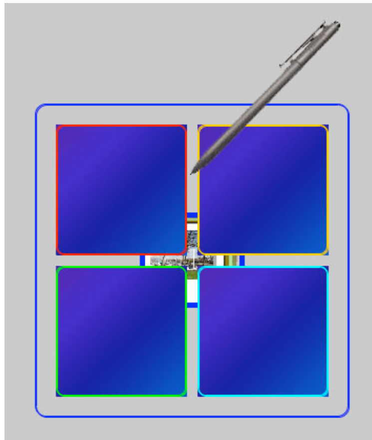
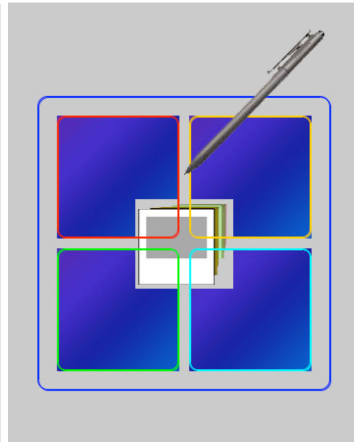
Feature	Requirement
The four user panels on the large display allow 4 different pictures to be displayed simultaneously.	Displaying multiple pictures on the Large screen by means of slides show or an arrangement of multiple photos on the Large screen.

Ease of Use: Multiple pictures can be easily added to the 4 different user panels. This gives the users the opportunity to compare different pictures or integrate it in other actions such as story telling as discussed above.

Visual Feedback: The user can clearly see the different pictures on the user panels on TO which are highlighted with the corresponding user-panel colour.

13

Feature	Requirement
A slide show function, where the user drops a stack of photos on one of the user panels and views the slide show on the Large Screen (and the TP). Or where the user drags the TP on a stack of photos and views a full-screen slide show on the Large screen	Displaying multiple pictures on the Large screen by means of slides show or an arrangement of multiple photos on the Large screen.
	

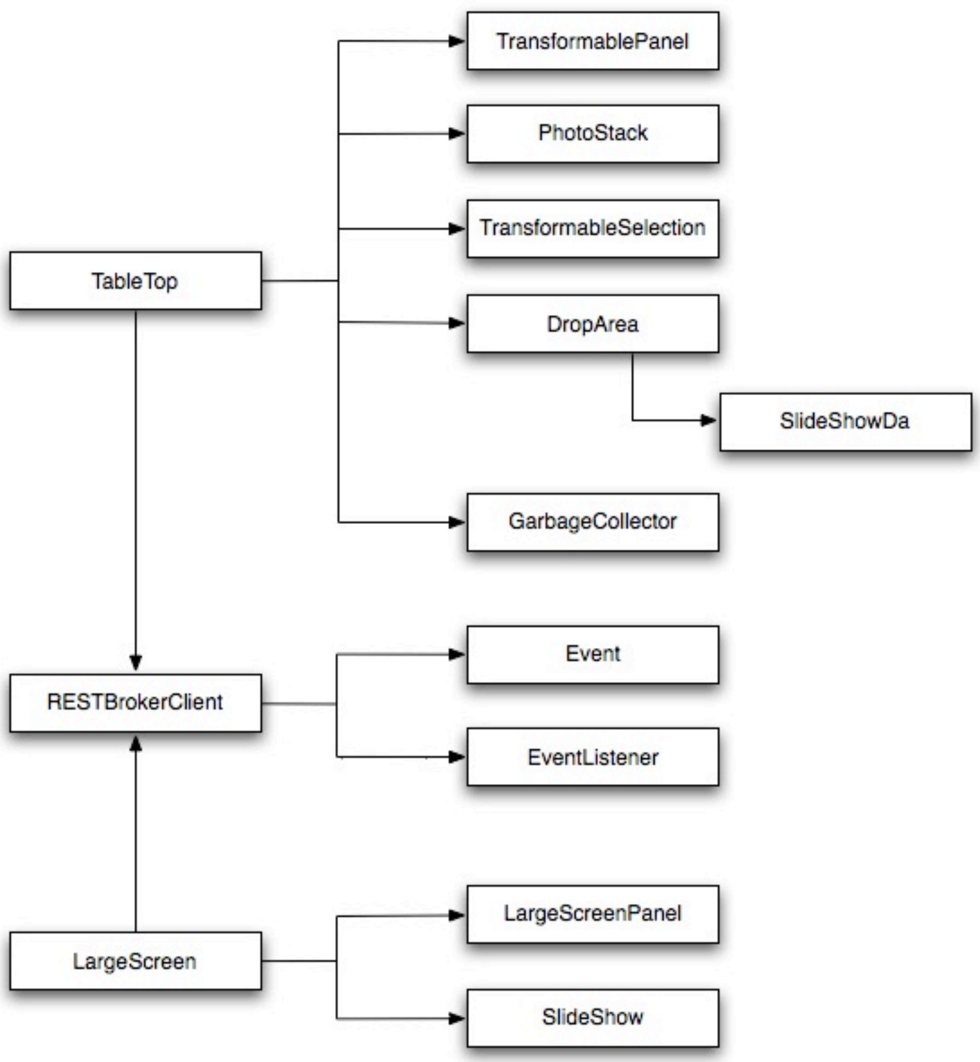
Ease of Use: Sliding a stack of photos onto one of the user-panels on the TP is easy and clear. When this action is executed, the stack icon is added to the TP and the user views a slide show of all the pictures of the stack on the Large screen.
This slide show can be removed by dragging the stack off the TP.

Visual Feedback: When the stack is placed on the TP, the stack icon is highlighted with the appropriate colour (corresponding to the appropriate user-panel).

Software

Classes

In this section depicts the class structure of the system and the interdependencies between the classes. Next we will continue discussing these classes and their significant methods and attributes.



Tabletop

This is the main class, it provides the communication between the different classes. All the other components will have TableTop as an attribute, so it is possible to ask the TableTop about the other components.

TableTop
DropArea droparea GarbageCollector gc ArrayList<TransformablePanel> alltps ArrayList<PhotoStack> allps
loadPhoto() sendPhoto(String panel, TransformablePanel photo) sendPhotoStack(String panel, PhotoStack stack) onSelectionMakeStack(Point begin, Point end)

Attributes

- droparea
  The DropArea that is on the table.
- gc
  The GarbageCollector that is on the table.
- alltps
  ArrayList with all the TransformablePanels that are on the table.
- allps
  ArrayList with all the PhotoStacks that are on the table.

Methods

- loadPhoto()
  Loads all the photos when the application is started. Makes a TransformablePanel of the photos.
- sendPhoto(String panel, TransformablePanel photo)
  Sends a photo to the Large Screen, and let the large screen know on which panel the photo has to be shown.
- sendPhotoStack(String panel, PhotoStack stack)
  Sends a photostack to the Large Screen, and let the large screen know on which panel the slideshow has to be shown.
- onSelectionMakeStack(Point begin, Point end)
  Makes a stack of the selected photos.

TransformablePanel

This class represents the photos that are on the table. The photo should be able to be dragged or scaled on the table, so a JPanel is used for this.

TransformablePanel
DropArea droparea TableTop tabletop ArrayList<TransformablePanel> allTPsOntt
setRandomCoord() checkOnGarbageC() checkOnDroparea() checkOnSelection(Rectangle tp) getOnThisPanel()

Attributes

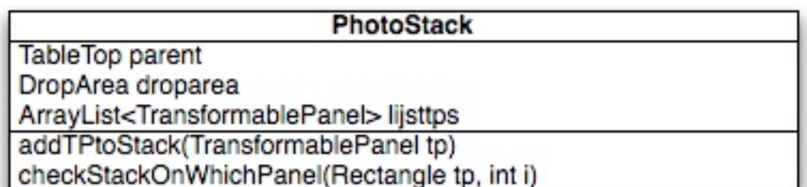
- droparea
  The DropArea that is on the table.
- tabletop
  The parent, where all the other components are on.
- allTPsOntt
  ArrayList with all the TransformablePanels that are on the table.

Methods

- setRandomCoord()
  Set the random coordinates for the TransformablePanel.
- checkOnGarbage()
  Returns a boolean, if the TransformablePanel is on the GarbageCollector or not.
- checkOnDroparea()
  Returns a boolean, if the TransformablePanel is on the DropArea or not.
- checkOnSelection(Rectangle tp)
  Returns a boolean, if the TransformablePanel is in the Selection that is made.
- getOnThisPanel()
  Returns the name of the panel of DropArea, where the TransformablePanel is added to.

PhotoStack

This class represents a stack of photos. It contains a list of TransformablePanels, which represents the photos.



Attributes

- parent
  TableTop is the parent, where all the other components are on.
- droparea
  Droparea that is on the tabletop.
- lijsttps
  ArrayList with all the TransformablePanels that are in this stack

Methods

- addTPtoStack(TransformablePanel tp)
  Add a TransformablePanel to the PhotoStack
- checkStackOnWhichPanel(Rectangle tp, int i)
  Returns the name of the panel of DropArea where the PhotoStack is added to.

DropArea

This class represents the medium that is used by the user to send their photo up to the large screen. The DropArea contains five different panels, four panels are smaller and are used to show the photos on normal size and the fifth one is used for showing a photo full screen.

DropArea
TableTop parent
setPanelEmpty(String naampanel, boolean panelempty) getPanelEmpty(String naampanel) getDaOnThis() checkOnStack() checkOnPhoto()

Attributes

- parent

  TableTop is the parent, where all the other components are on.

Methods

- setPanelEmpty(String naampanel, boolean panelempty)

  Set this panel on DropArea to be empty, this means that it does not contain a photo or photostack.
- getPanelEmpty(String naampanel)

  Return a boolean if this panel on the DropArea is empty or not.
- getDaOnThis()

  Return the TransformablePanel where the DropArea is on. This could be done by dragging the DropArea, or release the DropArea on the TransformablePanel.
- checkOnStack()

  Return a boolean, if the DropArea is on a PhotoStack or not.
- checkOnPhoto()

  Return a boolean, if the DropArea is on a TransformablePanel or not.

SlideShowDa

This class represents the slideshow on the DropArea. When the user drops a PhotoStack onto the DropArea, there will be a slideshow shown on the large screen, but also on the DropArea for the users feedback.

SlideShowDa
ArrayList<Image> images ArrayList<String> urls Thread runner
showImages (ArrayList<Image> images) run() start() stop()

Attributes

- images

  ArrayList of all the images

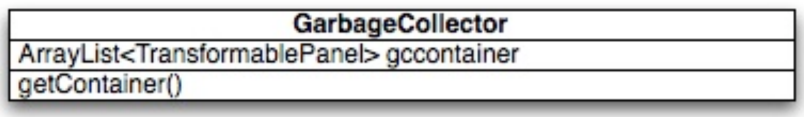
- urls
  ArrayList of all the names of the images
- runner
  Thread used to start the slideshow

Methods

- showImages(ArrayList<Image> images)
  Show all the images from the given list of images.
- run()
  Run the thread
- start()
  Start the slideshow
- stop()
  Stop the slideshow

GarbageCollector

This class represents a garbage can, when the user want to remove a photo from the table, the user has to drag the photo onto this GarbageCollector.



Attributes

- gccontainer
  ArrayList with all the TransformablePanels that have been removed by the user.

Methods

- getContainer()
  Return the ArrayList with all the TransformablePanels that has been removed by the user.

RESTBrokerClient

This class provides the communication between the TableTop and the LargeScreen.

Methods

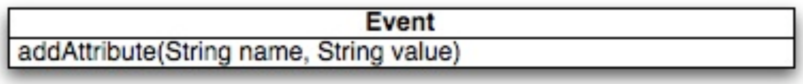
- subscribe(String channel)
  Subscribe to a single channel, adding it to the channels already ubscribed to.
- startListening()

Start listening.

- sendEvent(String channel, Event event)
  Send an event to the channel.
- getEvents()
  Get pending events on the channel, or wait some period of time for a new event to appear (blocks for 30 seconds currently).

Event

This class enables the TableTop to send photos to the LargeScreen, by making an event and send this event to the LargeScreen.

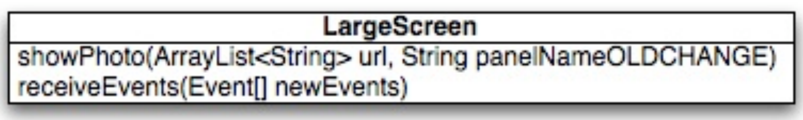


Methods

- addAttribute(String name, String value)
  Add an attribute to the Event.

LargeScreen

This class represents the large screen, where all the photos and slideshows are showed on.

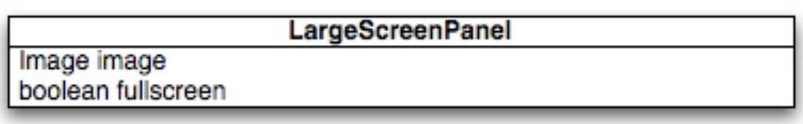


Methods

- showPhoto(ArrayList<String> url, String panelName)
  Show the photo on the Large Screen.
- receiveEvents(Even[] newEvents)
  Receives an Event every time the TableTop is sending an Event.

LargeScreenPanel

This class enables a photo to be shown onto the large screen.

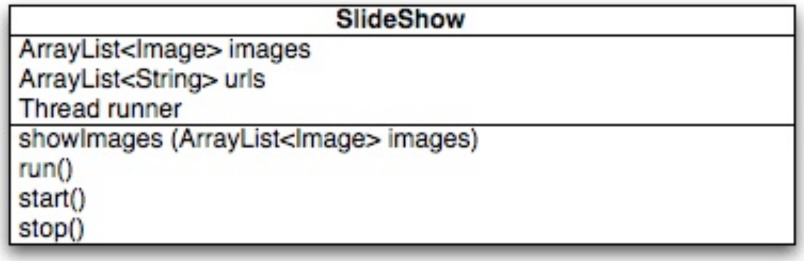


Attributen

- image
  Image that has to be shown on the LargeScreen.
- fullscreen
  Boolean is true if the image has to be shown fullscreen, else the boolean is false.

SlideShow

This class represents the slideshow on the large screen.



Attributes

- images
  ArrayList of all the images
- urls
  ArrayList of all the names of the images
- runner
  Thread used to start the slideshow

Methods

- showImages(ArrayList<Image> images)
  Show all the images from the given list of images.
- run()
  Run the thread
- start()
  Start the slideshow
- stop()
  Stop the slideshow

Final prototype

We finalised our prototype by making a few adjustments. The shapes were made softer with rounded edges and more appropriate colours to make the system more attractive.
This prototype consists of three important components:

(i) Interactive tabletop
(ii) The Teleporter Pad
(iii) Large Display

The final product is an interactive photo sharing application. A virtual interactive tabletop is used as a digital light table, providing a transparent and intuitive way of manipulating photos and other digital media suing simple gestures.

The application is attractive, easy and fun to work with. The users were excited to use it and were attracted to both the idea of an interactive digital surface such as a tabletop, and projecting the visual media on the Large Display.

Integrating the virtual tabletop with a shared large display has shown to be very successful. Users sitting around the table can view the media with the same angle and in an enlarged form, regardless of their location around the table.

We've developed the Teleporter Pad that acts as a fluid interface between table and display, providing the user with a tool to transfer media from the virtual tabletop to the shared display.

Our first prototype is an intuitive system that combines a virtual tabletop and a large display through our Teleporter Pad mechanism, providing a powerful metaphor for interacting with digital media in collaborative workspace.

Prototype2:

After completing the first prototype, decisions needed to be made concerning the direction that we would move towards. The first option was to continue working on the first prototype and add functionality to it, and the other option was to change our direction. After discussing what our options were and which goals we wanted to achieve we realised that extending the first prototype will not help us study the benefits and disadvantages of interacting with large displays further, nor will it help us research other aspects of integrating a collaborative workspace with a large display.
Therefore we decided to examine other ways of interacting with a large display, using a digital tabletop.

Design

The results of the first user test showed us which aspects of the interaction with the tabletop were favourable and a great improvement to the existing applications. These features therefore were kept in the design of the second prototype.
In this prototype, we wanted to design and study a new interaction tool with the Large display that would be placed on the digital tabletop. Very recently the notion of 'currents' is being used on existing interactive tabletops to give the users better control and access to the virtual objects located on the surface of the tabletop. This idea of currents can be used in a different way; a controlled current can flow from the tabletop to the large display and back to the tabletop. We decided to study how we can design an interactive tool to provide such a current as an interaction mechanism with the Large display.

In the following section the initial and general concept design for this prototype will be discussed. Next the individual design choices will be explained and. Finally some of the different scenarios corresponding to the possible functions in the system and their matching concept drawings will be presented.

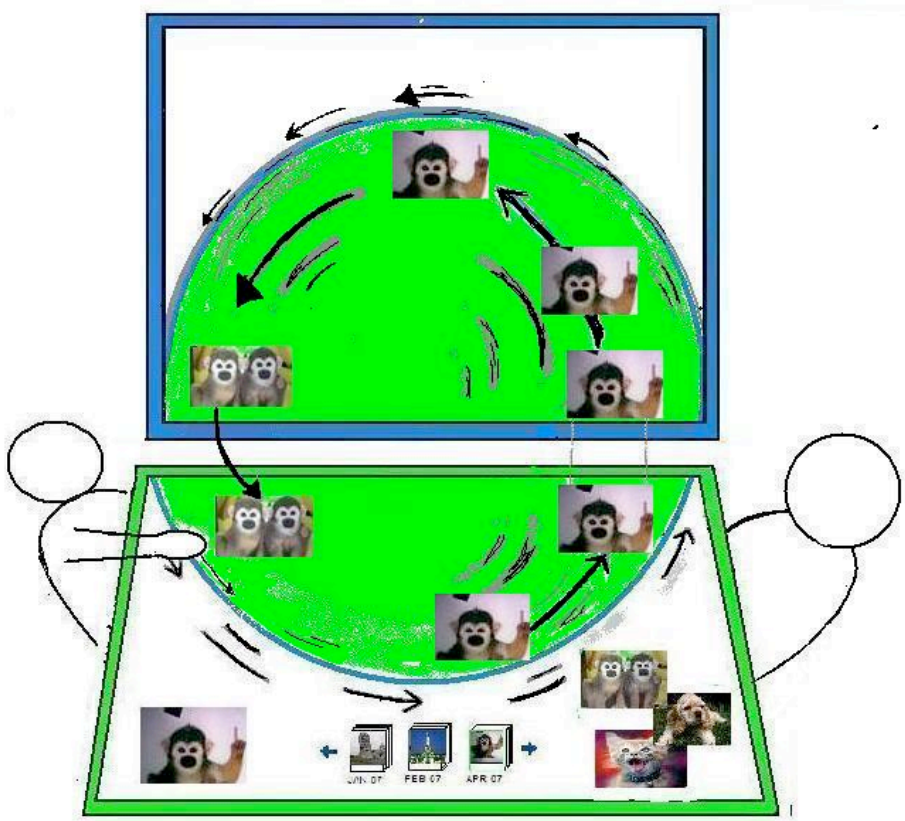
User interface Design:

Since tables are used as a metaphor in our application, we decided to use another real life tool related to tables, to inspire the design of the new interaction tool.
In the rich Chinese cuisine culture many different side dishes are shared by big groups sitting a around table. They have therefore designed a tool called a 'lazy Suzan' which is a round spinning plate placed in the middle of the table, where users can for example put a salt on the table and transfer it to the other side of the table by rotating the lazy Suzan.
A similar notion can be used in the same manner to transfer digital pictures from the tabletop to the Large Screen.

This tool can therefore be used as a metaphor to design an interaction tool that provides a controlled current of digital media from the tabletop to the Large Display and vice versa.

Therefore we decided to design a ‘ Virtual Spining Wheel’ simulating the lazy Susan, where half of our round Virtual Spining Wheel is placed on the tabletop and the other half can be viewed on the Large Display.
The users can use this to transfer photos to the Large Display by simply turning the round Virtual Spining Wheel until the photo reaches its destination.
Rotating the ‘Virtual Spining Wheel’ creates a controlled current that transfers the content of the half of the space located on the tabletop onto the Large Display.
When a user rotates the Virtual Spining Wheel with a certain angel all the pictures that are located on it (both on the tabletop half and on the Large screen half) rotate with that same angel.

In this way users can lay out the pictures as they want on the half of the Virtual Spining Wheel that is located on the tabletop and simply rotate it to transfer this structure to the Large Screen. At the same time the content of the Virtual Spining Wheel on the large Screen half is transferred back to the tabletop.

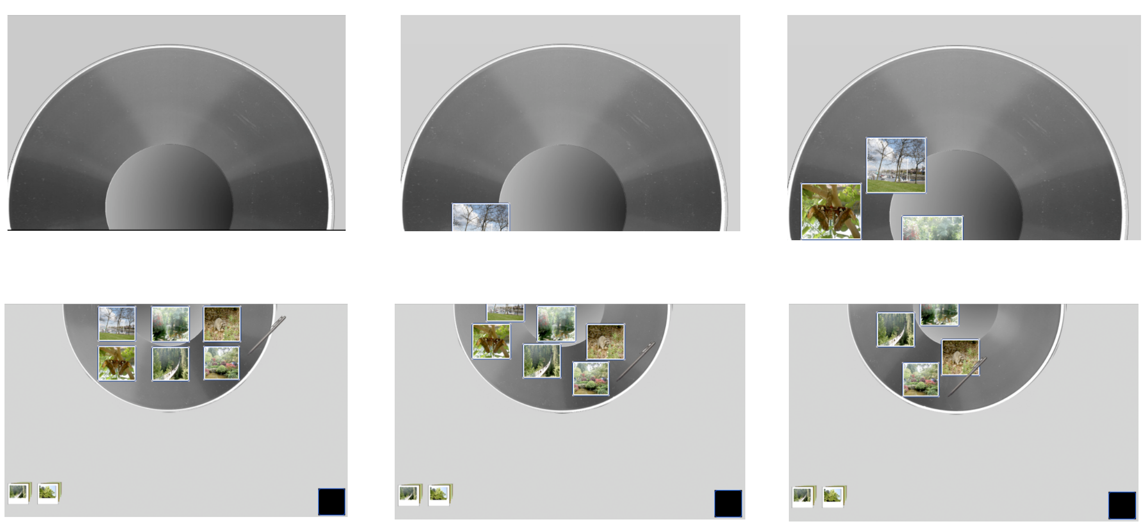


This design is very flexible and provides the user with the following Features:

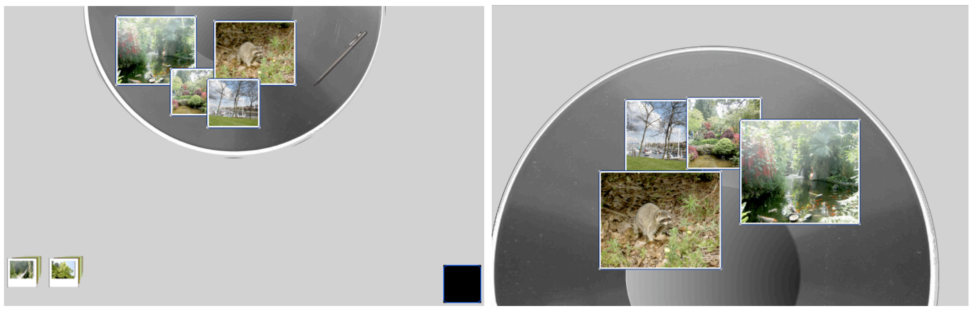
(i) The user has complete control over every point of the display space;

(ii) The users can freely place multiple pictures in their desired composition and display that very same structure on the large display.

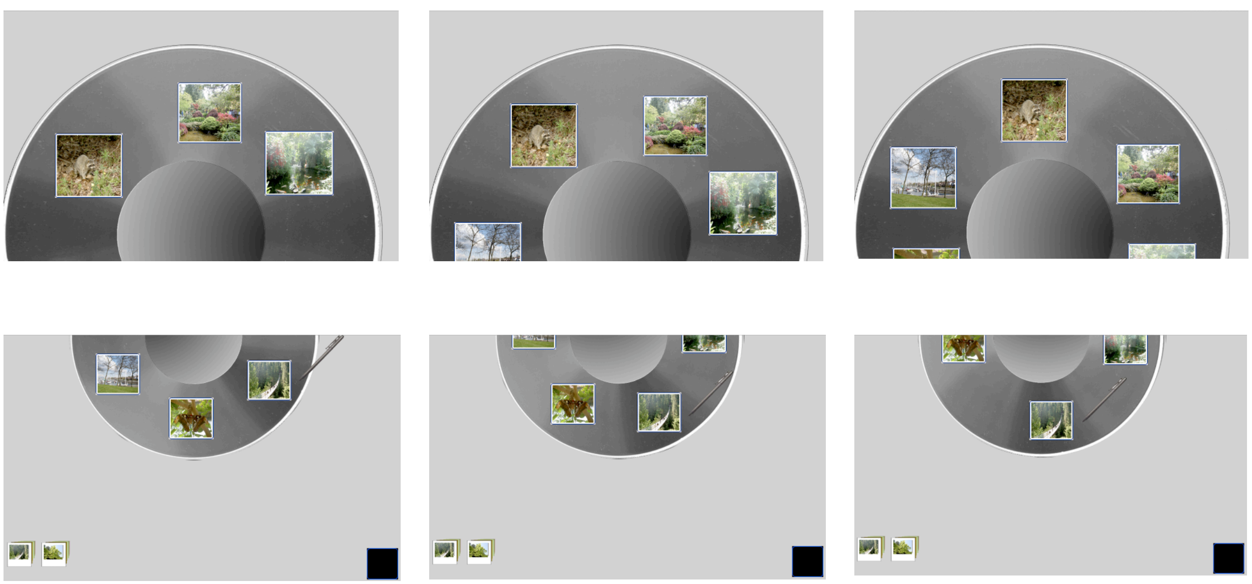
(iii) The number of the pictures displayed on the large screen is dynamic; The users can display as many pictures as they want at the same time.



(iv) The composition of the Large display is very flexible;
Users can be more creative arranging their pictures in their own desired composition.



(v) The users have total control over the composition and order of the displayed media;
They can choose to play all the pictures at once or create a flow, by spinning the table slowly and displaying the pictures in a slow current. This property of the system makes many collaborative activities easier (such as story telling).



(vi) The size of the displayed media is dynamic and controlled by the user;
The system always augments the artefacts on the Large Display, but it also allows the users too choose and alter the extent of augmentation.
The users may choose to rescale the pictures before displaying them on the Large Screen. They can freely display different pictures in different sizes.

(vii) Using this tool, many pictures can be transferred to the large Display at once and be transferred back to the tabletop;
The content of the virtual wheel is transformed by a simple rotation.

(viii) This approach is dynamic and gives the user the freedom to transfer the pictures only partly on the Large screen as they build the rest of their structure.
They can choose to keep some of the content on the large display while removing other parts.

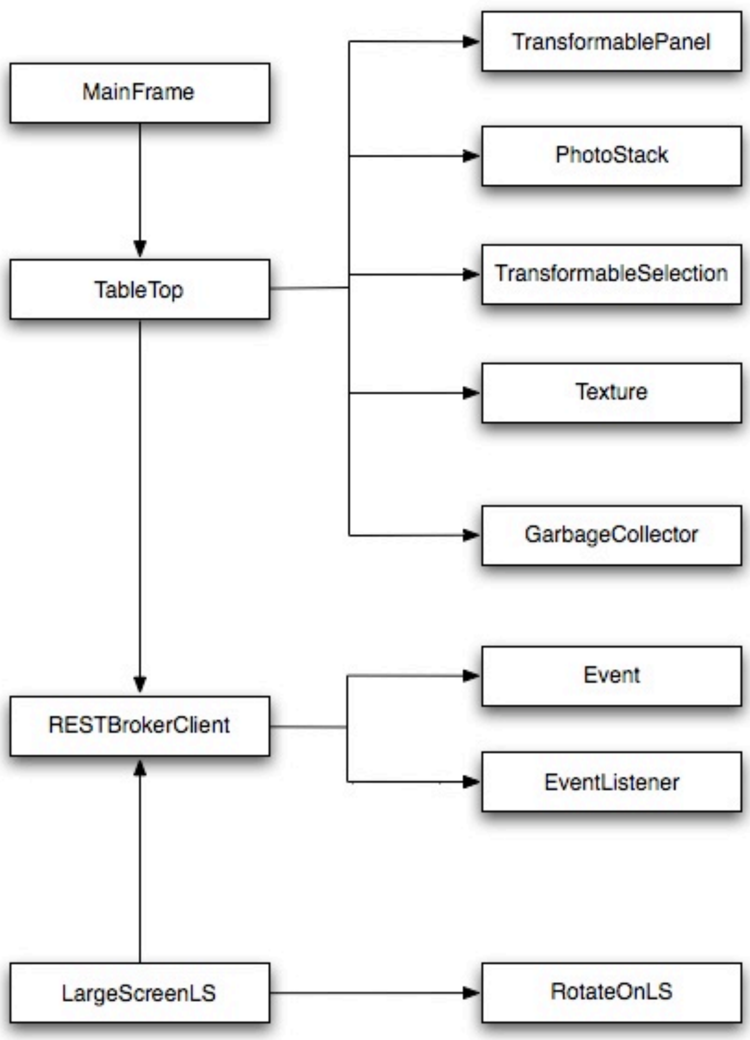
This design maintains the Feature1- Feature7 of the prototype1, preserving the interaction elements with the digital tabletop, which both full fill the functional requirements of the system and are very user-friendly, intuitive interaction tools.

The Virtual Spining Wheel replaces the functionality of the Teleporter-Pad, which provides the user with a flexible way of interacting with the Large display.
This tool allows the users to easily display individual or multiple pictures on the Large display and freely remove pictures from it.

Software

Classes

In this new prototype some of the classes of the previous prototype are reused. For these classes there are made some references back to prototype 1. Some classes are made easier and contain fewer methods, because there is no droparea in this prototype.



Mainframe

This class is the main and paints the tabletop onto the frame.

MainFrame
TableTop tabletop

Attributes

- TableTop tabletop

TableTop

This class provides the communication between the tabletop and the large screen. TableTop is also important for rotating the spinning wheel.

TableTop
Texture tx ArrayList<Shape> shapes ArrayList<Boolean> booleans double thetaStart double thetaSendStart double prevThetaStart double prevThetaEnd double deltaTheta boolean turned
setOnCircle(boolean b, int thisx, int thisy,int deltax,int deltay,int width, int height, TransformablePanel tp, int removecounter) sendAdd(String photoname, int x, int y, int w, int h) sendThetaStart(double tthetastart) sendTheta(double ttheta) sendThetaEnd(double tthetaEnd) sendRemove(String index)

Attributes

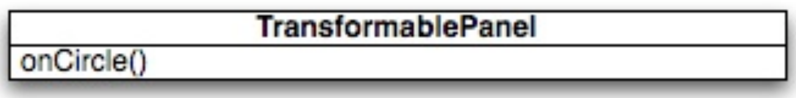
- Texture tx
  This is the texture on the tabletop.
- ArrayList<Shape> shapes
  This list contains rectangle shapes, used so the TransformablePanels can be rotated.
- ArrayList<Boolean> booleans
  This list contains booleans, these booleans are set to true when a TransformablePanel is released on the rotating wheel.
- double thetaStart
  The first theta when the wheel starts to rotate.
- double thetaSendStart
  ThetaStart to send to the large screen.
- double prevThetaStart
  Previous theta start.
- double prevThetaEnd
  Previous theta end.
- double deltaTheta
  Difference between thetaStart and thetaEnd.
- boolean turned
  Is true when the wheel is rotated.

Methods

- setOnCircle(Boolean b, int thisx, int thisy, int deltax, int width, inht height, TransformablePanel tp, int removecounter)
  When a TransformablePanel is released on the rotating wheel, their information like their position and boundings are set.
- sendAdd(String photoname, int x, int y, int w, int h)
  Send add to the large screen.
- sendThetaStart(double thetastart)
  Send thetastart to the large screen.
- sendThetaEnd(double thetaEnd)
  Send thetaend to the large screen.
- sendRemove(String index)
  Send remove to the large screen.

TransformablePanel

This class represents the same photos that are on the table as in Prototype1. The photo should be able to be dragged or scaled on the table, so a JPanel is used for this.



Methods

- onCircle()
  Checks if the TransformablePanel is on the rotating wheel.

PhotoStack

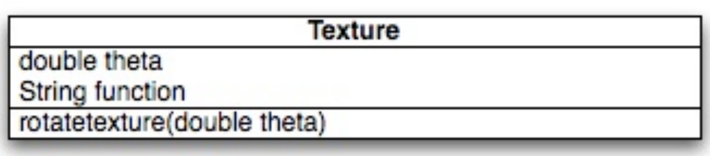
See Prototype1: PhotoStack

TransformableSelection

See Prototype1: TransformableSelection

Texture

This class contains the texture for the rotating wheel.



Attributes

- double theta
  Theta is the angle, to rotate the Texture with.
- String function

This String is used to make a difference between the texture on the large screen and the texture on the tabletop.

Methods

- rotatetexture(double theta)
  This method rotates the texture with the given angle.

GarbageCollector

See Prototype1: GarbageCollector

RESTBrokerClient

See Prototype1: RESTBrokerClient

EventListener

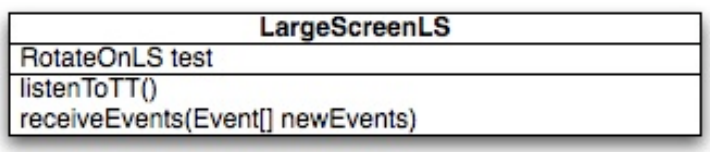
See Prototype1: EventListener

Event

See Prototype1: Event

LargeScreenLS

This class represents the large screen and is the frame for the other half of the rotating wheel.



Attributes

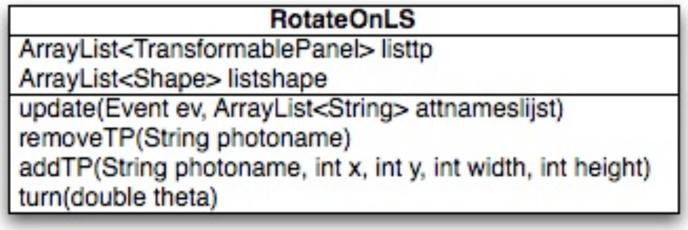
- RotateOnLS test
  This is the other half of the rotating wheel.

Methods

- listenToTT()
  This method makes a connection with TableTop
- receiveEvents(Event[] newEvents)
  This method receives the events sent by the TableTop

RotateOnLS

This class represents the other half of the rotating wheel on the large screen.



Attributes

- ArrayList<TransformablePanel> listtp
  This ArrayList contains all the TransformablePanels on the large screen.
- ArrayList<Shape> listshape
  This ArrayList contains all the shapes corresponding to the TransformablePanels, so the TransformablePanels can be rotated.

Methods

- update(Event e, ArrayList<String> attnameslijst)
  When the large screen receives an event, this method is called, to update the large screen.
- removeTP(String photoname)
  Remove the given TransformablePanel from the large screen.
- addTP(String photoname, int x, int y, int width, int height)
  Add the given TransformablePanel to the large screen.
- turn (double theta)
  Turn the rotating wheel and all the added TransformablePanels on the large screen.

Final prototype

This prototype consists of three important components:

(iv) Interactive tabletop
(v) The Virtual Spinning Wheel
(vi) Large Display

The interactive tabletop again acts as a workspace that can be shared by several users, where they can interact with digital photos.

This horizontal surface is integrated with a Large Display in order to improve view ability of the digital media for a group of users.

The Virtual Spinning Wheel acts as an interaction tool with the Large display. This tool is used to transfer data from the tabletop to the large display in a dynamic and flexible manner. The user can place the media on the virtual wheel and rotate them to the other side, where they will appear on the Large Display.

The Virtual Spinning Wheel provides a structured way of interacting with the Large Display while giving users a tool to control over the flow and appearance of the digital media, allowing for creating interactive storyboards.

Prototype3:

In the second prototype the concept of ‘controlled currents’ was used to transfer digital media from the virtual tabletop to the Large Display. This notion however can also be used to ease photo sharing in other ways. One of the observations made in the first prototype was the lack of control over pictures that were located far away from the user (for instance across the table on the other side). This make made it difficult for the user to reach these pictures before processing and displaying them. We therefore decided that the concept of currents can be used here to provide users with better access. In this section the process of design and testing of the system will be discussed the final product will be illustrated.

Design

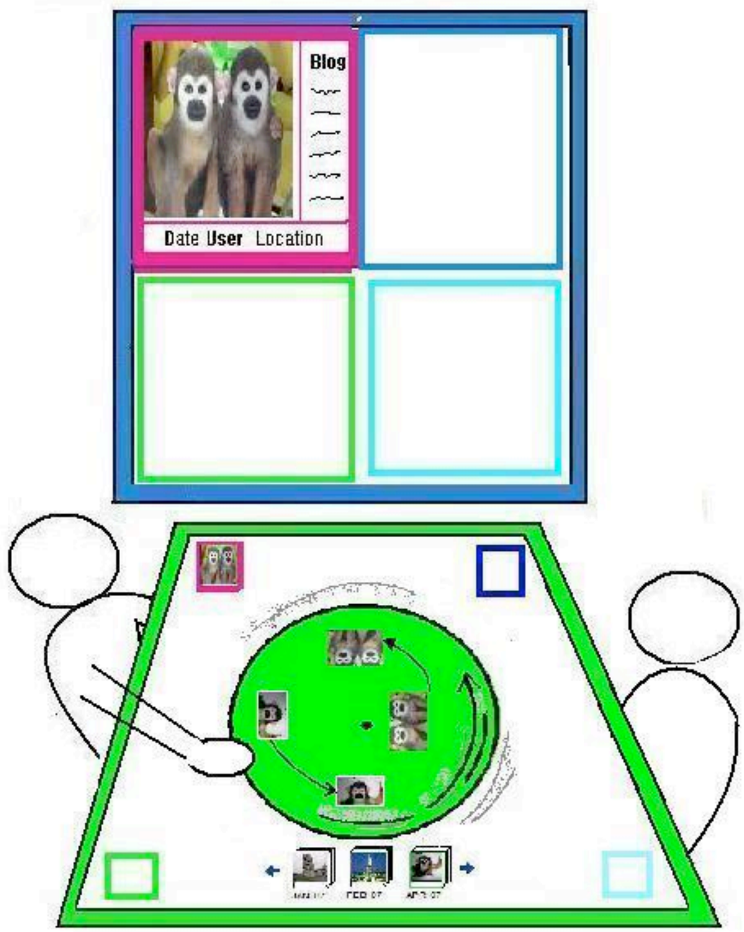
Having learned many things about interactive digital surfaces and shared Large Displays from the first two prototypes, we decided to use a combination of the successful interaction features from both prototypes to build the third and final product.
As mentioned above we decided to use a flow of currents to ease photo sharing and provide users better access to the digital media files on the tabletop. There fore we came up with the following two scenarios:

(i) The first design concept was based on the fact that real life ‘Lazy Susan’ is used as an object-sharing tool. Using this notion as a metaphor we decided to design a system where a ‘Virtual Spinning Wheel’ is used as a tool to share photos on the digital tabletop. Many features on the virtual tabletop were successful in the first two prototypes and therefore were maintained in the third one. Since the ‘Virtual Spinning Wheel’ was used as a photo-sharing tool we decided to use the Teleporter-Pad as an interaction tool with the Large Display.

Following these design elements, we came up with a system that combines the first prototype and the ‘Virtual Spinning Wheel’.

In this scenario the different users sitting around the table each have their own Teleporter-Pad (which consists of only one user panel) that corresponds to one of the panels on the large display. They can share the photos and reach the ones that are not close to them using the ‘Virtual Spinning Wheel’ that is placed in the middle of the table.

The users can place the photo on the ‘Virtual Spinning Wheel’, and spin it until it reaches its destination. As soon as a picture is placed on the ‘Virtual Spinning Wheel’, it spins around with the other photos when a user rotates the ‘Virtual Spinning Wheel’.



(ii) The second concept design maintains most if the features of the first one while introducing a new notion into it.

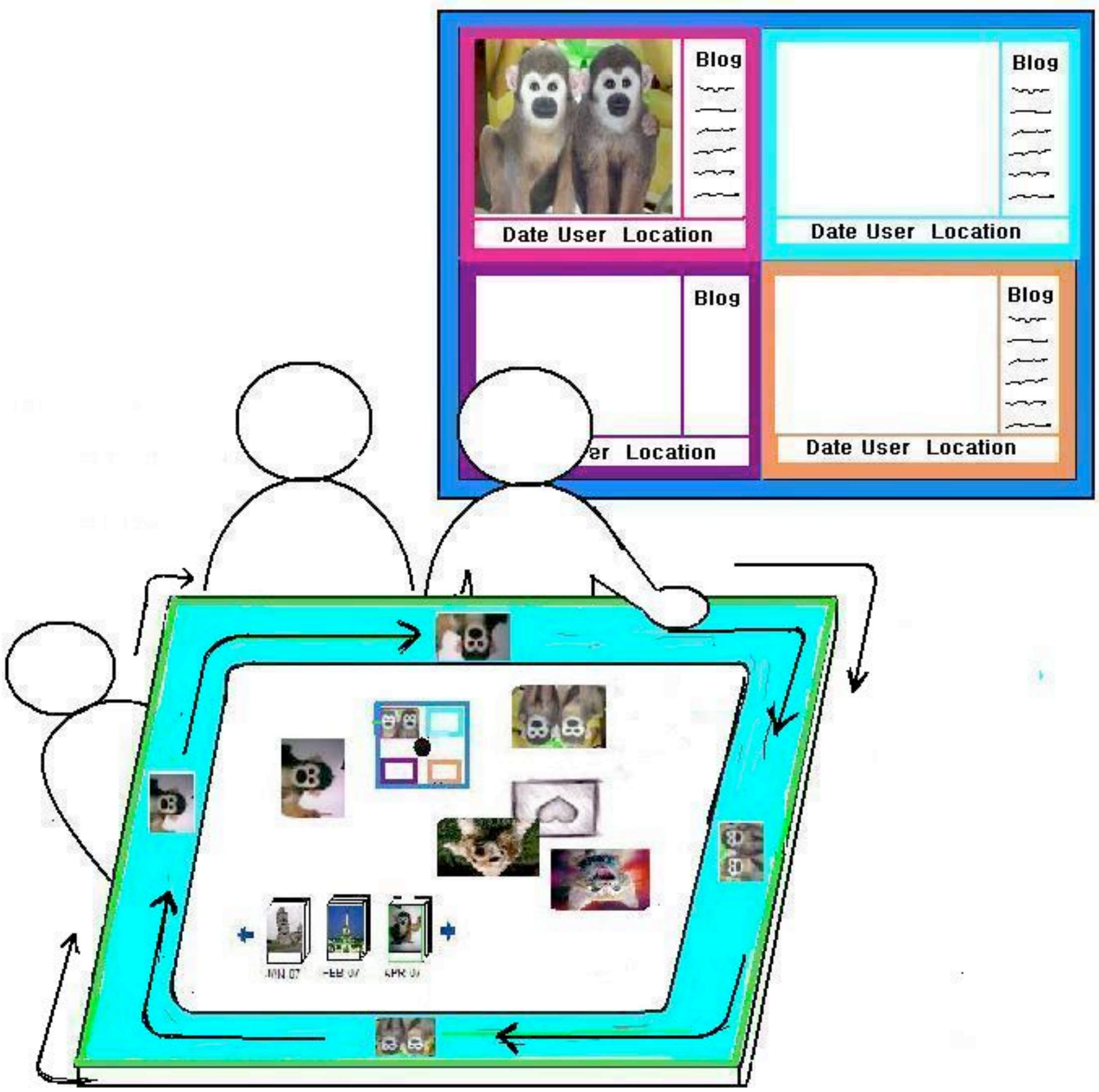
This scenario institutes a new way of combining our first two prototypes. Here the current of digital media files flows on the edges (border) of the tabletop. User can place photos on this ‘flowing path’ and use to send it to other users sitting around the tabletop.

The middle of the tabletop is used for other operations and includes the ‘Teleporter-Pad’, which is used to transfer photos to the Large display. There are three main features that differ from the first design concept:

1.The first is the space division between the different elements on the tabletop; here the edge of the tabletop is used for photo sharing and the rest is used for other operations that are carried out by all users including interacting with the Large Display.

2. Unlike the first scenario there’s one ‘Teleporter-Pad’ that will be shared by all users, this tool is mainly located in the middle of the table but can also be placed on the edge of the tabletop to be sent to other user and easy accessibility.

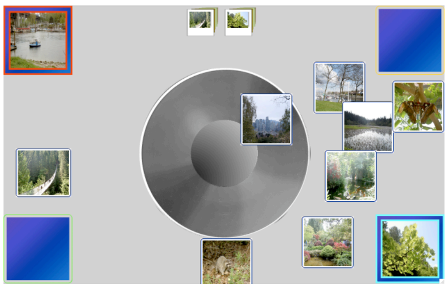
3. The flowing current around the table is a **constant** current that can still be controlled by the users; The user can speed up the current by dragging the edge of the tabletop, in this way all the photos located on the flowing edge travel faster around the tabletop.

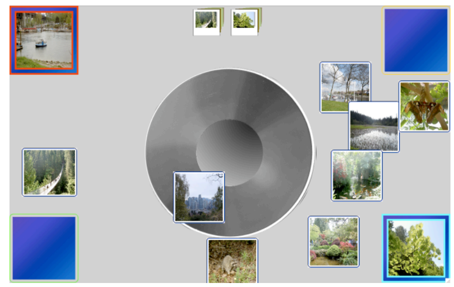


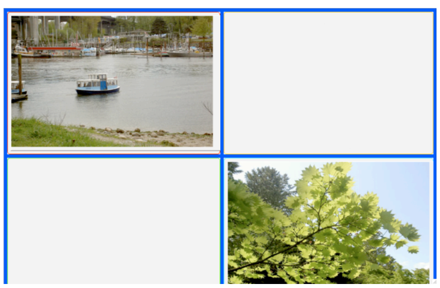
Selected Concept:

We chose to implement the first concept design, which consists of a Virtual Spinning Wheel located in the middle of the table, based on the following factors:

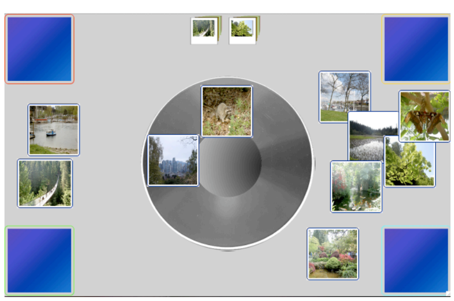
- Having a separate Teleporter Pad for each user, allows us to extend our research in the area of collaborative work spaces; we can find out weather users prefer to share an interaction tool with the large display or to each have complete control and constant access to their own area on the Large display .

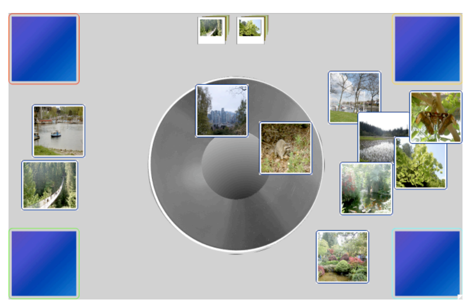


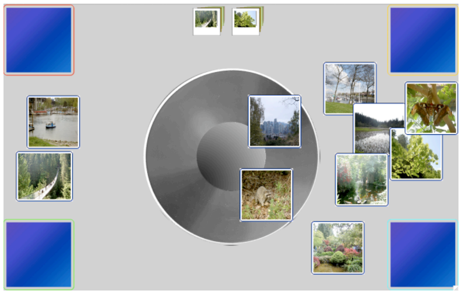


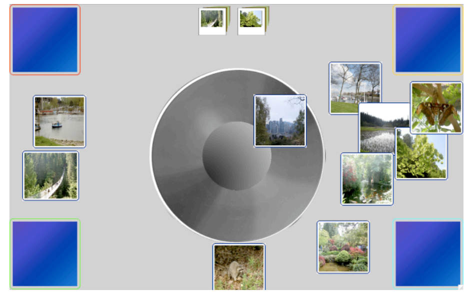


- The Virtual Spinning Wheel provides a perfect metaphor, simulating a real life physical object that is used for the same purpose(Lazy Suzan). This gives the users a sense of reality and allows them to interact with the system using intuitive gestures.









- Having a constant flow in the second concept design is likely to create a displaying tool which might distract and confuse the users between the two display surfaces.
- Combining the features of our existing prototypes provides us with comparative measures, and allows us to examine our existing system further.

Final prototype

This prototype consists of three important components:

(i) Interactive tabletop
(ii) The Virtual Spinning Wheel
(iii) Teleporter-Pad
(iv) Large Display

The interactive tabletop serves as a shared workspace where photos are manipulated and shared.

The Virtual Spinning Wheel provides a tool to share photos on the tabletop. The users can use this tool to send photos to each other simply by placing the photo on the wheel and spinning it to other side. Provided some social interaction, this tool gives the users access to photos regardless of their location on the tabletop.

The digital photos are displayed on a large display that is split into 4 regions. Each region corresponds to a user sitting on one side of the table.

The users interact with the large display using the four Teleporter-Pads located at the four corners of the table. Each user has access to one of the Teleporter-Pads, which is projected on ¼ of the area of the Large Display.

This prototype was built to east file sharing on the digital tabletop and to, grant users with complete control over their own area of the shared Display.

User study

In order to test our system and investigate the advantages and disadvantages of the two different interfaces between the tabletop and upright display, we carried out a user study. In this section the goals and process of the user study will be illustrated and the results will be discussed.

Goals:

This study was carried out to help us evaluate our deign choices and understand the ueres favoured mechanism for interaction with Large Display.

The Goal of this study was to help us answer the following questions about the first two prototypes:

General questions:

1.Is the interaction with the tabletop intuitive, or does it distract users from performing their main tasks?

2.which functions are not intuitive and how can they be improved to enhance usability?

4.how users distribute and use the workspace on the virtual tabletop.

5.Do users prefer to share their media using the Large Display and why?

6.how do users deal with a large amount of pictures on the workspace?

7.how long does it take users to learn the functions and use the system comfortably?

8.How does interaction with tabletop augment the existing applications?

9.how do users interact with sets of photos?

10. Is the Teleporter Pad an intuitive interface?

11.Is the Virtual Spinning Wheel an intuitive interface?

Comparative measures:

1.Do users prefer to interact with the large display through the Teleporter Pad or the Virtual Spinning Wheel?

2. Which tool is more efficient for transferring data to the Large Display?

3.Which tool is more convenient for the users for displaying an ordered set of photos?

4.Which tool is more convenient for the users for displaying a set of photos, when order is not of importance?

User Test:

The user test was designed to investigate the usability of the system. The tasks given to the users are more complex task tat requires the users to engage more in the tasks rather than focusing their attention on interacting with the digital tabletop.

The following tasks were given to the users to complete both on the first and second prototypes.

The first task was designed to investigate the preferences of the users when an ordered set of digital artefacts are involved.

Task 1. Make a storyboard for a comic book.

You will be given four tacks of pictures; Each of the first three stacks contains pictures of one of the characters from the Garfield comic book, and the last one is a stack of pictures with two or more of the Garfield characters .

Stack1. Garfield
Stack2. Jon
Stack3. Odie
Stack4. Garfield, Jon & Odie

(i) Choose 6-8 pictures from the stacks in order to tell a story. The pictures used in the storyboard must include at least one picture from each stack.
(ii) Rearrange your storyboard as many times as you need.
(iii) Share and display your story using the Tabletop and Large Screen.

The second task was designed to provide comparative measures, and investigate the behaviour of the users when a set of pictures with relative context us involved, where order is of no importance.

Task 2. Make a sport collage.

You will be given one stack of pictures of corresponding to different sports, and one stack of headlines about the different sports.

Stack1. Photos of different sports.
Stack2. Headlines corresponding to the different sports.

(i) Match at least three of the headline with their corresponding sports pictures (for example there can be three pictures corresponding to the headline about basketball). You may choose one or more pictures of the corresponding sport.
(ii) Arrange them on the Tabletop.s
(iii) Share and discus them using the Tabletop and/or the Large screen.

Results & Analyses

The user test was carried out using 4 test persons. The users interacted with the product in different ways. They seemed to be working with the system comfortably without prior training. The tasks mainly required individual decision-making and design, and shared display and story telling. The observations made and questions asked from the test users helped answer the questions asked in the last section. These will be discussed shortly.

General questions:

1.Is the interaction with the tabletop intuitive, or does it distract users from performing their main tasks?

Interacting with the photos resembles interacting with physical objects, as you can move them around with simple gestures. Other interaction functions such as re-scaling the photos are standard desktop functions that are familiar to the user and don't need to be learned.

The users could interact intuitively with the tabletop using both prototypes, and could figure out the most functions easily without prior knowledge about the system. The users could mainly focus on the tasks given to them. The only problem was caused where there were too many photos on the tabletop, which at some cases created some distraction.

2.which functions are not intuitive and how can they be improved to enhance usability?

(i)There were some problems while creating new stacks of photos.

> -It would be useful to be able to alter stacks; add/remove pictures to/from them.
>
> -The only way of identifying a stack is by the first photo, which is useful, but since there can be double photos it would be more efficient to add tags to stacks. And create a search function where the users can search through the stacks using tags.
>
> -Currently it is not possible to determine the order in which the photos are piled up in a stack; this feature is desired in cases where a set of ordered digital media is being displayed.

(ii) Problems concerning the trash can element:
The trashcan was a very useful tool that we implemented to avoid clutter. In the initial design the trashcan was only made available for photos and not for stack of photos. This choice was made based on the fact that deleting a whole stack of photos at once causes a lot of data loss and might not be desirable.
Users however tended to attempt to delete stacks often to keep only their desired photos on the tabletop. The trash element can be improved by making it possible to delete stacks from the tabletop, and allowing the users to recover the media that was deleted, if desired.

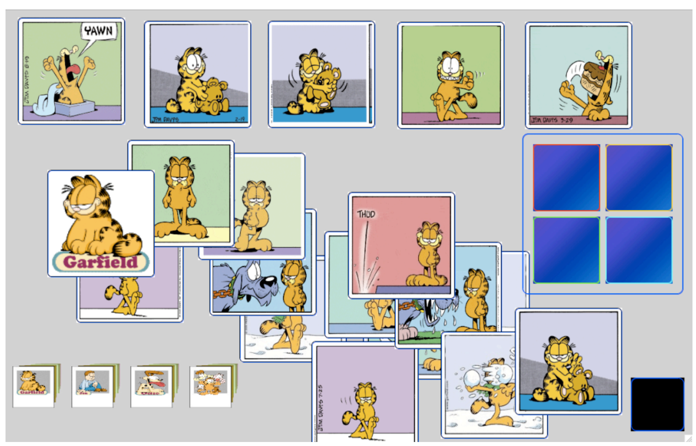
(iii) Storyboard

There was an observation made mainly while users were interacting with the first prototype (Teleporter Pad); Users seemed to tend to create a region for story boarding. They would add their photos to this region and try to close the stack that the picture belonged to, in order to avoid clutter. Their initial expectation was that the photos would stay. In the area where they created the story board. But since in practice there was no region designed for this purpose, the photos would be piled back up, when the stack was closed. A future improvement would be to create a separate region for story boarding where users could add photos and maintain their composition of photos even when their stack was closed.

This was not a problem when using the second prototype, since the area of the Virtual Spinning Wheel could be used for story boarding. This came to the users intuitively as they used this area for this purpose without being told that that was the function of the area.

3.how do users distribute and use the workspace on the virtual tabletop?

The user seemed to tend to organise things into regions. A region for storyboarding, a region for content of stack 1, a region for contents of stack 2. Etc.



4.how do users deal with a large amount of pictures on the workspace?

The users dealt with a large number of photos on the table in several ways;

-They opened one stack at a time.
-They threw unwanted pictures in the trashcan.
-They created new stacks to put unwanted photos aside.

5.Do users prefer to share their media using the Large Display and why?

All users were enthusiastic about displaying their media on the Large Display. In the case of story telling the tool was very effective, since they could work with small sized pictures on the tabletop, and display these photos in a Large size and in a sequence on the

Large Display. The audience were sitting around the table, but all of their attention was focused on the Large Display and not on the tabletop, which shows that they could view the photos much better on the Large display.
The storyteller could also use different functions to display the data one by one in the pace that they needed, while having prepared the complete storyboard beforehand.

6.how long does it take users to learn the functions and use the system comfortably?

It generally takes the users a couple of minutes to familiarize themselves with the system. This was a successful result.

7.How does interaction with tabletop augment the existing applications?

Interacting with the pictures on the tabletop simulates interacting with physical objects and is more intuitive than the existing applications.

8.How do users interact with sets of photos?

The notion of stacks was very often used by the test users. They used this notion for several purposes. They used it to display a set of related media. They used it to collect a set of context related media. They used it to remove unwanted pictures from the tabletop. They used it to organise the photos into separate collections.
They often closed all the stacks to clear the tabletop surface and then would open only the one that they needed, extracting their desired pictures form it, closing the stack and moving on to other stacks.

9. Is the Teleporter Pad an intuitive interface and does it provide sufficient control over the Large Display?

The Teleporter Pad was easily accessed by the users. The visual feedback provided by the four panels of the Teleporter Pad corresponding to the four user panels of the Large Display, gave the users complete and direct control over the displayed media. There was how ever a lack of control over the composition in which this media was being displayed. The user could only display the media in the rigid, pre-defined structure.

10. Is the Virtual Spinning Wheel an intuitive interface and does it provide sufficient control over the Large Display?

The users were very enthusiastic about displaying their photos using the Virtual Spinning Wheel. This medium simulates a physical spinning object, with the advantage that the media placed on the virtual wheel actually travels all the way to the upright display and back to the tabletop, which is impossible in real life. This gave the users Complete control over the structure and composition of the media that was being displayed and offered a dynamic size for the displayed photos.

Comparative measures:

1.Do users prefer to interact with the large display through the Teleporter Pad or the Virtual Spinning Wheel?

In general the preference of the users was to use the Virtual Spinning Wheel due to its attractive appearance and its innovative way of transferring media to the large Display, which resembles a real life tool.

2. Which tool is more efficient for transferring data to the Large Display?

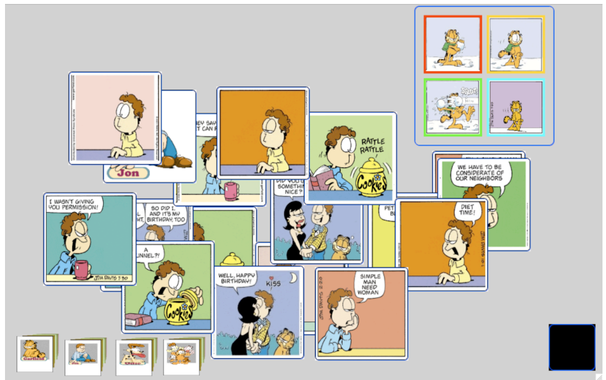
The Virtual Spinning Wheel can transfer a variable number of photos to the Large Display. This tool however does not make optimum use of surface of the Large Display. The photos can not be displayed in their maximum possible size, and a section of the Large display is not being used to display any pictures.
The Teleporter Pad however, limits the number of photos displayed at once, but provides the possibility of using every inch of the Large display to exhibit media, and allows the users to display the photos at full size.

3.Which tool is more convenient for the users for displaying an ordered set of photos?

This was the case while the users were dealing with the comic book pictures in the first prototype. The pictures needed to be displayed in a certain order to allow the users to tell their stories.
The users created and displayed their storyboards for the first task, using the Teleporter Pad in the following different ways:

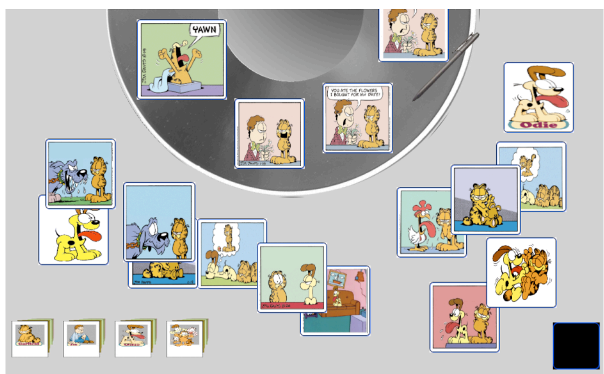
(i) The users created a stack of their photos and displayed a slide show using their new stack. This caused many problems since the users could not decide the order in which the pictures were displayed and therefore their story could not be told as they wished.

(ii) The users first added 4 pictures to the four available panels on the upright display, they then removed them and added a new set of pictures to complete their story. This was more successful, since their story could be told, as they wanted. This also allowed the audience to view more than only the picture that the user was talking about, which was some times a desirable feature, whereas some users did not want their audience to see the upcoming pictures. The inconvenience here was that the number of pictures played at a time was limited, and the users had to actually add these pictures during the story telling and could not prepare it in advanced.

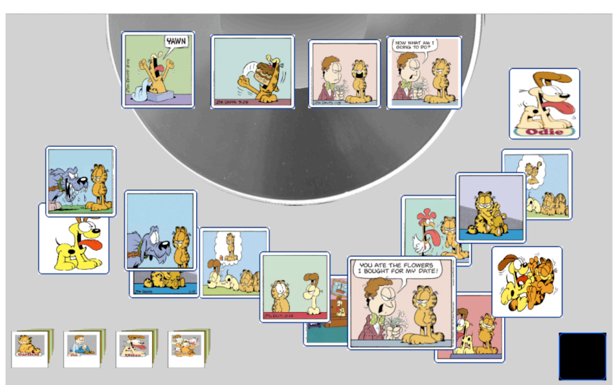


The users created and displayed their storyboards for the first task, using the Virtual Spinning Wheel in the following different ways:

(i) 3 out of 4 users preferred to use this tool to display their storyboards. These three users chose to display their pictures using the controlled current provided by the wheel. They set all their desired pictures in the order they wanted on the wheel prior to displaying it. They then rotated the Wheel, showing their pictures one by one in a smooth flow, while telling their story.



(ii) The one user however laid the pictures out in a grid structure on the wheel and displayed the composition at once. He preferred the direct control that was granted using the four panels of the Teleporter Pad.



In general users prefer to use the Virtual Spinning Wheel when an ordered set of media

files is involved, since it offers features to maintain this order while displaying it, and offers a way of displaying photos in a stream.
This tool is also more useful for creative activities, such as design, since it provides the users with the possibility of displaying their desired composition on the upright screen.

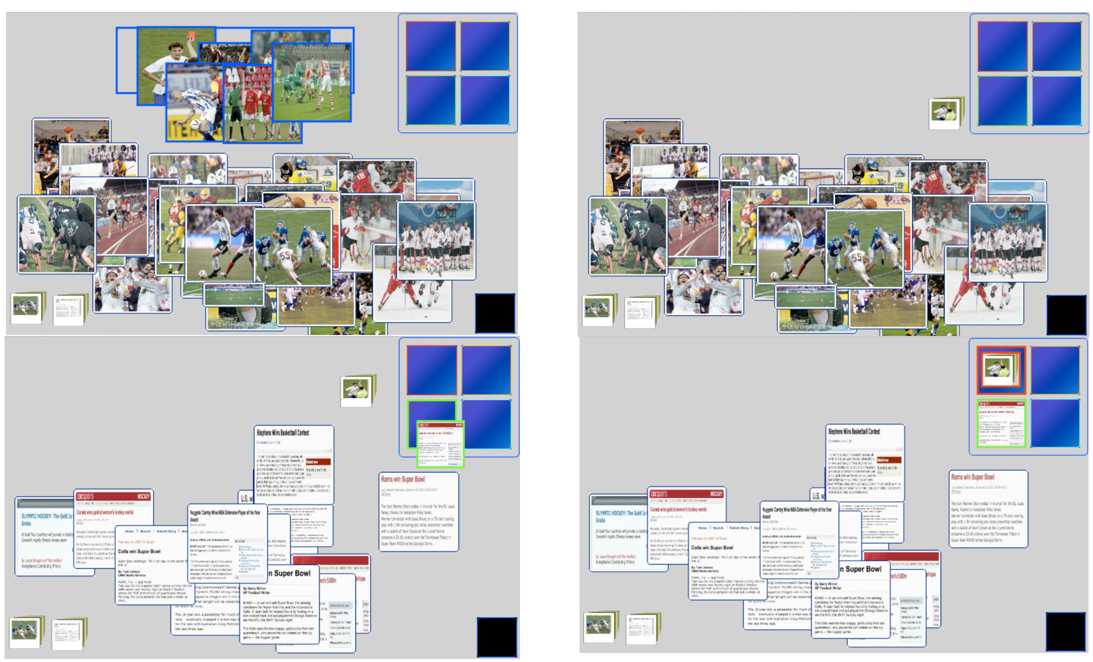
4.Which tool is more convenient for the users for displaying a set of photos, when order is not of importance?

This was the mainly case while the users were dealing with the sport pictures and articles in the second prototype. While the displayed media were related in content, and this relation was to be clearly viewed on the Large display, they did not need to be displayed in a certain order.

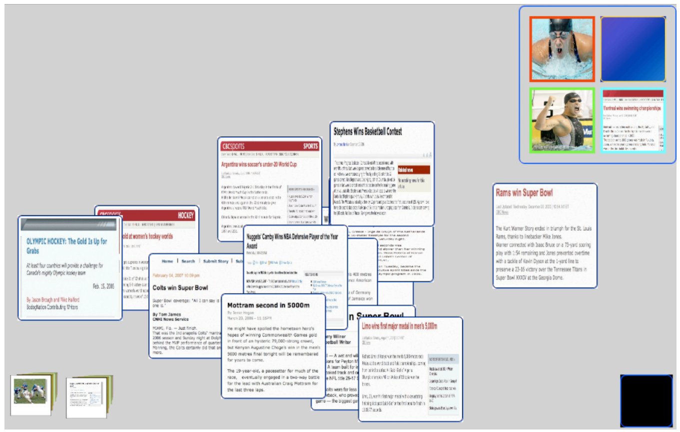
The users created and displayed their digital media files for the second task, using the Teleporter Pad in the following different ways:

(i) They piled up the related articles and pictures in separate stacks, and displayed the corresponding slide show.

(ii) They displayed the article of their interest in one panel and piled up the related pictures in a stack, and displayed the corresponding slide show in the adjacent panel.



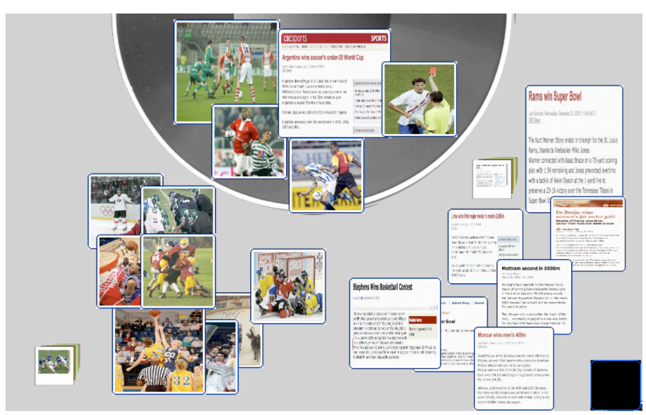
(iii) They displayed the article of their interest in one of the four panels, and displayed 3 of the related photos in the remaining display panels. This limited the number of photos that could be viewed at once.



The users created and displayed their digital media files for the second task, using the Virtual Spinning Wheel in the following different ways:

(i) The users increased the size of the articles almost in all cases to be able to read the text clearly.

(ii) They displayed the pictures in a random composition of photos and the related article in a form of a collage.



(iii) Some users displayed theirs selected article first and followed by the related pictures (one by one).

In general the users preferred to use the Teleporter Pad in order to display a set of data where order is not of importance, but where they need to display multiple photos, this was mainly due to the slide show function, and the rigid and structured composition of the Large Display.

User study Conclusion:

The results showed that users find the notion of displaying their media files on a Large Upright display very appealing. This helps the audience view the media with the same perception and viewpoint as the creator of it.
The two interaction tools were compared in this user study, each of the tools proved to be more convenient for certain tasks.
The users were generally more attracted to the Spinning wheel that envisions a physical tool to transfer virtual objects from one point to another using simple gestures. He dynamic nature of this tool granter the users with freedom and flexibility over the composition, size and order of the displayed pictures.

The rigid structure of the Teleporter Pad however did offer advantages where a set of un-ordered set of photos was involved. The visual feedback provided by this tool, and the direct control over the content of the Large Display granted to the user were very attractive features. The slide show function provided by this tool, eases displaying a collection of related media files. The optimum use of the Large Display allows the users to display their photos in enlarged form, which permits the audience to view the detailed version of the photos.

Future Improvements

The system was built on a tablet-pc, which was used to simulate a Digital Tabletop. This tool did not allow us to permit multiple inputs at once, and therefore allows the users to interact with the tabletop only one at a time. Our system however is designed to ease collaborative activities. This prototype can be best implemented on a multi-touch surface, where multiple users can interact with the tabletop at once, using their fingers.

The current system uses different regions for keeping separate elements; (regions are provided for the stacks, photos, interaction with the Large display). This notion can be further extended to offer separate regions for other activities such as story boarding. This makes the workspace easier to use and more clearly for the users.

In the third prototype the spinning wheel was used on the tabletop to ease photo sharing. Other tools can be used for this purpose. People often 'throw / slide ' objects to send them to another location on a physical tabletop. This throw gesture can be simulated on the digital tabletop, and can be an efficient way of transferring digital media on the tabletop. This function could also be used to transfer media from the tabletop to the upright display, the throw force can for example be measured and if the photo is 'thrown hard with enough force' it will reach the Large Display.

The notion of measuring the force inserted by the user in a certain gesture can be extended to measure the force and direction in which a user rotates the Virtual Spinning Wheel(both in prototypes 2 & 3). This 'force' can then be used to rotate the wheel further after the user releases it until the, just as a real spinning object would in real life. In this way the real physics of the rotation action can be reflected; if the user rotates the wheel with a lot of force it keeps on spinning for a long time, and if not it stops shortly after the user releases the wheel.

Finally, the system can be further extended by providing other possibilities, for instance directly adding notes to the photos on the tabletop, or adding music files to certain media files or stacks of photos. Adding such features to the application extends the areas of where it can be used, and makes the system more attractive and fun.

Future possibilities and alternative applications

This prototype can be used and implemented in many different areas and can be used to create many different applications.
The system can be implementing by using multiple Large Displays, and/or multiple interactive horizontal surfaces.
The digital tabletop and upright display can be used in boardrooms & seminars to ease cooperative decision making. They application could be used to facilitate collaborative storytelling and design used in many different areas.

Conclusion

Today, when digital documents are shared, people are still constrained to used personal work spaces. To enhance face – to – face collaboration, while using data, digital surfaces can be used to simulate the real life tables and wall-mounted displays.
Using an interactive digital tabletop, allows user to manipulate digital media collaboratively, using simple gestures.

A digital tabletop offers fflexibility by allowing users to layout shared documents with desired orientation and position on the surface of the tabletop.

The haptic nature of interaction with a digital tabletop, makes it intuitive and easy to use, as apposed to the standard keyboard and mouse based applications.

This application was therefore built on a digital tabletop for the purpose of interacting with and sharing digital files. Using only this horizontal surface however, limits the users to viewing the digital media in small sizes and with different viewing angles depending on their relative position around the tabletop.
In order to enhance the visibility of the digital media and to provide the same viewing angle for all users, we integrated a large Display in our application. The digital media transferred to and displayed on an upright large display. This shared display creates a fixed point in an dynamic environment, while enhancing the involved media.

In this study two interfaces were made between the digital tabletop and the upright display to allow the user to access the shared display through the interactive tabletop.

The first interface called the Teleporter Pad is a tool to transfer media from the tabletop to the display using simple gestures. This tool grants the user direct access to the content of the upright display and provides visual accessibility, which is critical to ubiquitous environments, through its rigid pre-defined structure.

The second interface called the Virtual Spinning Wheel visualises a physical wheel that rotates as the users spin its edges / surface. The contents of the wheel are in this way transferred to the display. This interface provides dynamic and flexible interaction with the Large display and gives the users a sense of continuity and reality.

The third feature that was added to the application was a photo-sharing tool on the table, which grants the user with access over the content of the tabletop, making it possible for users to reach objects located far from them.

This study shows that integrating an interactive digital tabletop with a upright shared display enhances the possibilities when multiple users are manipulating and sharing digital files as a group. It offers many advantages and provides intuitive interaction.

The interaction with the large display can be done through different types of interfaces. These interfaces must provide the user with visual feedback of the Large display and give users complete control and access to its content. Finally, the surface of the tabletop must be made accessible by all users.

This application simulates the reality while offering the advantages of a digital world, approaching an ambient environment.