Visual Scoping of Private Information Displayed on Shared Tabletop Surfaces

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Abstract—Informations sharing in meetings or conference calls are often done by displaying the information on a shared display, e.g. a projected or shared display, or a shared surface as a table. The amount of information on the shared surface may increase, and the clutter makes the relevant information hidden or hard to find. One challenge for current systems is to filter out the information without interest. Another challenge is adding information. For most current system, as information is added, it distracts the other participants as parts of the display is obstructed, or activity elsewhere on the display draws undesired activity. In this paper, we describe a novel system that fixes these challenges by filtering out unwanted information, or superimposing information that should not be displayed to everyone on a private display, thus providing a useful way of only working with the information of interest.

I. SURFACE AND COLLABORATION

Most of the information users consume on a daily basis exists in a digital form. The need to work with this digital information, and not the analog hardcopies, are evident in the sheer number of solutions emerging for sharing this information, like Google Docs, ZoHo Office, (the soon to be released) Microsoft Office Web Apps, Google Wave, DropBox and so on [1].

There are reports that as much as half of the working day at an office may be spent in meetings [2]. There are many solutions for improving the time spent in meetings, working and sharing information with those present. Projectors can be found in almost every meeting room, providing a convenient way of projecting the computer display on the wall. Many meeting rooms also have electronic white boards, capable of showing both the computer display and provide a surface for writing and drawing. Some of these smart meeting rooms, providing automatic note-taking, meeting transcriptions etc., are emerging [3–5].

A. Collaboration Surfaces

Microsoft Surface [6] provides similar functionality as the white board, but add more ways to interact with the display. The surface is usually presented as a table, and, for the user, it is a simple way of interacting with objects displayed on the table using hand gestures or pre-defined objects. New objects may be added using the normal file viewer, but can also be added using other means for recognizing object, e.g. the built-in camera. Touch screens are also now starting to be common, and is found in anything from public kiosks [7] to hand held devices.

Other systems also add the ability to interact and cooperate with remote users. The *C-Slate* [8] provides a touch screen for displaying and interacting with object, and video conferencing capabilities. It also uses a overhead video camera for detecting hand movement and transmits an image for the other participant to see, making it easy to know what the other users are doing, where they are pointing etc.

Common for all these are that they have a common display for all participants. Any information put on the display is instantly visible by everyone participating. Often, this is the desired behavior, but there are times when it is inconvenient, or even undesirable, to show other participants private information.

B. Information sharing

During a normal workday, there are many situations where we meet to have a discussion or solve a problem. Participants bring papers, pens, laptops etc. to these meetings, each participant bringing their own set of tools. Sharing the information on a display requires a projector, or other shared displays, to allow the rest of the participants to see the images, text, slides etc.

Sharing a display means sharing everything on the computer display with anyone watching. There might be parts of the information on the computer display that for privacy reasons should not be shared, but that it is convenient to have available. A salesman may not want to disclose what the minimum acceptable price is, and the buyer may not want to share the total budget. It is also possible that the information is confidential. A medical doctor may need to look up a patients record, but a patients record is confidential and may not be shown to just anyone.

In other instances, the information may not be secret or confidential, but it is not necessary for the discussion and would only clutter the view for others. Sometimes it is necessary to get new information on to the display, but finding the information might take some time. Rather than stopping the discussion while the information is located and displayed, the ability to locate and position the information on the display without disturbing the view for others is useful.

Many of the problems described above may be solved by having personal papers, laptop etc., but this approach tends to keep the information private even when or if sharing is necessary. Also, having many papers and/or laptops on the table often distracts and clutters the work area. Many systems end up failing as they do not take the usability and privacy of the system into account [9, 10]. In this paper we will describe a system addressing some of these challenges.

II. A System for Presenting Scoped Information

A. The setup

We have created a prototype of a system for displaying and interacting with information using commonly available components. The display consist of a table with a reflective (white) top, a projector that is projecting onto the table, and a computer to control the projected image (see Figure 1). In addition, the users of the system may connect using a hand held device such as an iPhone, iPod Touch or similar Wi-Fi or Bluetooth enabled mobile devices.

B. Privacy Using Personal Displays

Imagine the following scenario: There are three participants having a discussion around the table. The table shows a document they are currently working on, and a Web Browser with some relevant text for the discussion going on. As the discussion progresses, there is a need for specific graphics. One of the participants has this graphics privately available. Rather than disturbing the two other participants in their discussion, he picks up his mobile device and finds the requested file. The device then display a representation of the table with a representation of the file that can be moved and scaled (see Figure 2).

When the group is ready to view the information, the file is "uploaded" to the shared surface. Everyone may now use this new information, copying, pasting, changing and interacting with it.

C. Adding private information using a device

In this scenario, there is also three participants sitting at a table, but this time the table shows a blueprint of an oil tanker. The tree participants are working on designing the ship, and they are trying to finish the design.

As each participant have different specialties, they do not all need to see every aspect the blueprints at all times. Viewing all the pipes, wires, beams, nuts and bolts at all times is hard, as the display very quickly will become cluttered.

One of the participants complain that due to a supporting beam being in the way, it is hard to get an electronic switch box to fit, and wonders if it is possible to move the beam a little. The changes are quickly made to the hull. Using his mobile device, the plumber looks at the table. Using the camera on the device, an augmented reality image is displayed. The table shows the modified blueprints of the boat, and through the device (on the display of the device), the plumber sees the blueprint with the water pipes overlaid on the video image. The electrician sees the same blueprints through

Figure 1. This image shows the system setup. It consists of a projector mounted on a stand, projecting the image on to the top of a white table. It is possible to interact with the table in a variety of way, including mouse, keyboard and hand held devices (e.g. iPhone). It is both possible and desirable to add touch functionality, but our prototype does not support this as of the time of writing.

Figure 2. The device in the illustration show a representation of the image on the surface, and the user is able to select where the selected information is going to be located when it is displayed to everybody. The new element is the small window with the blue border.

his device, but only sees the electric wiring overlaid. Any adjustments that are necessary are made, and when everybody agrees, everything is shown in one picture to verify that there

Figure 3. The image on the left shows the surface as everyone sees it. The image on the right is seen through the device (in this case an iPhone), revealing more information than could be seen just by looking at the surface.

Figure 4. This image illustrates how one may use *anaglyph images* to filter information. The left image shows the scene as it appears without any glasses. The middle and right images show how the scene looks through red and cyan glasses respectively.

are no errors.

D. Hiding Information using Anaglyph Images

With the same setup as in the previous sections, anyone watching always sees everything on the table. Sometimes some filtering of the information on the display may be useful, and this may be done by using *anaglyph images*. Anaglyph images are the 3D images know from the early 3D movies and 3D images [11]. It uses colored images, typically red and cyan, to filter one image to each eye, thus providing the illusion of watching a 3 dimensional scene. The image, when looked at without 3D glasses, actually contains two images, one encoded with each of the two colors, red and cyan. The glasses then filter one image for each eye, and the 3D effect is achieved.

We use the same type of technology, but apply it in order to filter some information out completely. The image displayed on the table contains some information. The participants are using colored glasses, either red or cyan for both eyes, to filter out part of the information on the display. As one of the participants starts typing a new paragraph in the text, the others want to continue the discussion of what is already there. The participant typing marks the text using the red color (the text is marked as *optionally scoped*, see Section VI-A). The other participants, using red colored glasses, only see the other text, not the one being worked on. When the text is ready, it may be marked as public, and everyone will be able to see it.

III. ANAGLYPH IMAGES

As of this writing, 3D movies is a popular topic, with Avatar being one of the all time most popular movies. The 3D movies of today uses advanced polarization of the image to achieve the 3D effects, but 3D movies have been around for a long time. The first 3D movies that became popular used a technology

called *Anaglyph Images*, where two images are displayed using two different colors. The two images are superimposed, and being slightly offset, they produce a 3D effect when viewed with a pair of 3D colored glasses. There are several colors that may be used, but red and cyan seem to produce good results. The 3D effect is achieved as the glasses have one color for each eye, filtering each of the images to only one of the viewer's eyes.

Our prototype uses a similar, but slightly altered, version of this technique to produce images viewed bye one, or some, of the participants. Each participant has a set of single colored glasses, effectively filtering out everything on the display with that color.

IV. SCOPED INFORMATION

In this paper we discuss how to use a shared surface with several participants, and still make some of the information available to only one, or some, of the users. Using anaglyph images, images coded with different colors, we are able to effectively hide parts of the images.

Each participant is given a set of colored glasses. The glasses are either colored red or cyan, as opposed to 3D colored glasses, where each eye has a different colored glass. Using these mono colored glasses, all information shown on the display using that color is filtered out, making that information unavailable to the user. It would also be possible to use other technologies, such as active or passively polarized glasses [12], but modifying these are harder for stock components.

When a user adds some information to the display, it starts out as being visible only to that user, or other users wearing no eyeglasses, or eyeglasses with the same color. It is possible to interact with this information just as any other, the only difference being that it is displayed with a particular color. If the user wants to share the information with the rest of the participants, the object is moved to the shared part of the display, which means it changes to a color that everyone is able to see. As one would expect, it is also possible to move already shared information back to being only visible by some users.

We call this way of hiding information *Scoped Information*, as it makes the information available or unavailable only to the participants that are using the glasses with a particular color. The technique does not provide privacy, as it is easy to just remove the glasses to see the hidden information. In fact, removing the glasses would reveal both shared information, and hidden information for both of the two colors. It does, however, provide a way to make information that is irrelevant disappear from the view.

Having scoped information gives the user the ability to display information on the shared display without disturbing everyone. Opening a new file may now be done in a way that only disturbs the one that are doing the operation. When the information is ready to be shared, it may be made available to everyone with the press of a button.

V. Private Information

Scoped information, as described in the previous section, is very useful. It will, however, not prevent others from seeing the information on the display, but then it was never intended to so. There may be situations with a need for more privacy than is provided by colored glasses. In our prototype, we are able to provide more privacy by using a second device to display this information.

Using a table as the main display, any information that should be viewed by everyone is shown. Using a portable device, such as the iPhone, it is possible to add information to the display. The iPhone is equipped with a video camera, and when the table is viewed, the extra information is superimposed on what is actually displayed on the table, providing an augmented reality [13]. It is possible to use other technologies, such as optical or video see-through head-mounted displays (HMD) [14–16].

Using the mobile device, it is possible to both interact with the information already displayed on the table, as well as adding new information. As default, any new information added by the mobile device is considered to be private, and is only visible on that device. It is possible to share the information with others, which will move the information from the mobile device to the shared surface. It will keep being visible through the device, as it is now displayed on the table, but the device is no longer needed in order to view the information. It is also possible to move the information in the other direction, making previously publicly visible information private.

Private information may also be shared with only some of the participants, provided they have their own mobile device. By selecting to share the information, and selecting the users to share with, the information will stay private, but will be available to all of the selected participants.

This makes it possible to have private information on the table without using other privatization mechanism such as colored or polarized eyeglasses, but it may of course also be used in addition to eyeglasses. The use of the mobile device does have a few advantages over the colored glasses approach.

VI. Discussion

A. Privacy

In this paper, the notion of hiding information is discussed. It is important to understand that in this context, the information is not necessarily *private*. Using the colored glasses, the information is *optionally scoped*. It is necessary to wear the glasses in order to filter out some of the information. Switching glasses means switching filters. Removing the glasses altogether means no filtering is being done.

By using a mobile device, information may be added to the view. We call this *mandatory scope*. In this case, the scope is enforced, as the information is filtered using the mobile device, while optional scope requires no action to see all the information.

In either case, the information is not really private. Anyone may view all of the information filtered using colored glasses by just not wearing the glasses. Using the mobile device, information is added to the table that only one, or a select group of people, may see. This is more private, but only adds some privacy as anyone may take a peek at the mobile device.

B. Implicit intentional communication

Both of the previous information hiding techniques adds an element of intent. When the user is wearing the glasses, they show intent to filter out some of the information on the display. The color of the glasses also shows which parts of the information that are being displayed. Taking the glasses off show intent to view all of the available information, and also indication that no information may be hidden from this particular participant.

Using a mobile device also show some intent. Holding up the device indicate an interest in some information that is not currently visible on the table. The direction of the device indicates what part of the surface that is currently being observed.

VII. Summary

In this paper we have described a prototype for sharing information on a shared surface (table), while being able to have some filtering or privacy applied to parts of the display. This gives the participants in a meeting or conference call the ability to remove information that currently have no interest, or add information that is not of public interest yet. There is great value in de-cluttering the information display, as one may concentrate on the information of interest.

Using Anaglyph images, it is possible to filter out some of the information displayed on the surface. The participant may choose to wear glasses having red or cyan glasses, thus filtering out the information on the surface displayed using the same color. Using this technique, it is possible for two participants, or groups of participants, to work on the same surface, without being disturbed by the other participants' actions. We call this *optionally scoped information*.

We have also described the ability to use portable devices, such as an iPhone, to reveal more information than what is currently visible on the surface. By using the camera on the device, it is possible to superimpose information on top of what is shown on the surface. The device is able to track what it is looking at, and using augmented reality techniques, additional information, such as a document not to be share with the other participants, are made visible to only one, or a select group of participants. We call this *mandatory scoped information*.

VIII. Future Work

One obvious and very tempting extension is to use the surface for teleconferencing. Allowing several participants to share and work with the same data using different surfaces and at different locations would make the surface even more useful. Further, one could add functionality similar to that of the C-Slate [8], where it is possible to see the hands of other participants as they are interacting with the surface.

It would be possible to use one or more touch screens as the surface. Microsoft have their technology that is fairly advanced, but a more inexpensive solution might be to just connect a number (2 or 4 seems appropriate) of inexpensive touch screens, and let the user interact using these displays.

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