A Large, High Resolution Tiled Display for Medical Use: Experiences from Prototyping of a Radiology Scenario

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\textbf{Abstract.} The scope of the project was to assess the value of using high-resolution, very large displays in a hospital setting. We applied a scenario informed prototyping method and user-involvement in order to do this. Initial results suggest that the technology could prove very useful in clinical conferencing settings like the communicating process between the radiology department and the other hospital departments using their services. The possibility of bringing more visual information simultaneously to the audience is especially intriguing. However, issues such as floor control – who administers the (extra) information space and information-overload, are imminent in interface design and our prototype suggests that the clinicians do want functionality that stresses these issues.

\textbf{Keywords:} human computer interaction, large, high-resolution displays, radiology, user informed design

\section{1. Introduction}

The renaissance of very large, high resolution and (relatively) low-cost displays have been foreseen and expected for some years already. The transition from CRT monitors to LCD display panels and plasma screens with increasingly more pixels and larger size have to some degree already met those expectations, and video projectors are also reaching ever new heights in terms of image quality and resolution. However, even though technology, like large high-resolution plasma screens and LCDs have been introduced into clinical environments, like surgery, radiology and others (i.e. [1]), technology like a display wall (see Figure 2) has not been studied in such an environment before. The affordances of large, high-resolution displays have been studied for some years already [2], but not in terms of clinical use.

Jonathan Grudin stated in his 2001 study of multi-monitor use [3] that a typical large display only occupies about ten percent of your visual field we have when only moving our eyes. In the natural world we probably feel quite restricted by such a
narrow field of view. Large, high resolution displays allow us to both enlarge the image viewed and to be able to move close to it – without losing detail as you would with a regular projector. Recent research suggests that large display surfaces do provide certain benefits for the users [4],[2]. However, the large physical display provides an excellent common workspace for people to collaborate as well. A fair body of research within this context has been done in the last decades (see, i.e. [5] for an overview on this topic) and it is within this paradigm we believe that the major benefits from large displays truly lies. We have used a user-centered approach, including observations of users in real work activities, to inform the creation of a crude interface prototype for selected clinical conference situations.

2. Methods and materials

In our study we have used a scenario-based prototyping approach combined with observations of work activities at the Radiology Department to inform design and possible use of large, high-resolution displays in teamwork settings at a hospital.

The display wall is created from 28 projectors and an equal number of cluster nodes running the RedHat Linux operating system. The 28 projectors create, through hardware and software technology, a more or less seamless image that is 7168x3072 pixels – approximately 22 megapixels (see Figure 2). The Display Wall is approximately 220’ across.

We conducted some initial observations at the University Hospital of Northern-Norway (UNN). Based on the findings from those observations, one case was selected as the basis for design of a prototype. User-involvement was invoked on the level that the users were introduced to the capabilities of the display wall and the purpose of the demo was discussed. The Radiology department, being the selected case, then chose a patient case for the prototype and the image material along with textual information noted on the patient case was handed to the design team. Imaging material that was selected by the Radiology Department the patient case, consisting of DICOM formatted images and textual information was used to create a prototype interface for the display wall. We conducted a demo of the prototype where potential benefits of using a high resolution display like the display wall in a medical setting at the Radiology Department was highlighted and discussed. The main objective was to assess the qualities of a large high resolution display wall as a collaborating mechanism in the context of a typical radiology demonstration setting (scenario). Hence, the demo was thoughtfully planned to provoke discussion and reflection on what such technology has to offer. We videotaped the demo and comments were transcribed. Results from this demo are our primary findings.

In designing the prototype we had image material like CT, MR, CT-angio stitched together to a large enough image to fit the wall (22 mega pixels). For this purpose we used ImageMagick1 and borrowed the familiar interface from the current image viewer at the Radiology Department as a “frame” around the images (see Figure 2). We used a parallel image viewer, developed at the Computer Science department, capable of viewing images across the cluster of computers running the display wall in order to have a very responsive interface that do not require several seconds of loading when zooming and panning along the large images on the wall.

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1 www.imagemagick.org
To describe the prototype we built we use the framework that Houde and Hill presents in [6]; role, look-and-feel and implementation. Our prototype is developed along all the three dimensions. The role of the artifact is investigated by regarding the display wall as the communicating medium for the radiology team and staff from any other department in the hospital. Look and feel component is medium to high fidelity and resolution. We provide an actual looking interface on a real display wall. On the implementation side, this is a prototype with limitations in fidelity and resolution of the interface elements. We developed the scenario subsequent to the observations done at UNN. The scenario was not explicitly shared with the user group (radiologists), but was for internal use among the designers. The scenario: “A Radiologist is presenting a patient case to another department. The latter department has requested the images. The radiologist is using a 22 megapixel; the equivalent of 28 ordinary displays.” It is a very ambiguous and general scenario, although it describes the specific use of the artifact.

3. Findings

3.1. Findings from the observation

The observational studies performed were mainly done in order to look at the presently available equipment in the hospital and only to a limited degree to focus on how the tasks are actually performed. The first observation was performed at an oncology department at UNN. We observed a morning meeting at the oncology department and a weekly teleconferencing-educational seminar between the current Tromsø department and an off-site part of this department located in the city of Bodø. Using a display-wall for this scenario, we could i.e. expect a more sense of presence from the remote site at the local site having the display-wall [7] in the video-conference. However – we decided cooperatively with the oncology department not to pursue this scenario as a candidate for our prototype. The second observation was at a conference room located at the Pathology department of the University Hospital. We were given a demo of the equipment and an unstructured interview with one of the leading pathologists at the department was conducted. The conference room we were shown had room for approximately 40 people and is typically in use for conferences on for instance brain tumors, urology, mammography cases and gynecology. The equipment used in this facility was a 2-projector lineup with two screens, where one screen typically displays variable content depending on the case studied while the right displays the pathology image being selected by the person handling the microscope. We agreed that the pathology conference room was interesting for our scenario and that the pathologist would provide input to the prototype and be present at the demonstration. The third observation session was at a radiology meeting with a group of neurologists. Based on

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2 The oncology department is one administrative unit, but is physically divided by 1000km
the previous meetings and the discussions we had both before the meetings, during, and afterwards we already knew that the clinicians are used to large displays and a two-projector setup. That meant that we could advance somewhat and start looking for particular needs for the kinds of features the display-wall technology offers. We were looking for situations where additional information about patient was requested and where image material was browsed through, for instance where the method of scrolling through image material was used. Figure 1 shows a sketch of the setup at the radiology board. Notice the very typical setup of three computer screens for a radiology station and the two ceiling-mounted projectors used to show the images from the patient and communicate findings. The arrows from the computer screens illustrates that the image from these screens are shared to the audience. Typical here is that the imaging data is the only one being shared visually. If any other data is requested it is typically read out loud by the radiologist controlling the workstations PCs. A typical patient presentation proceeds like this: (1) the radiologist reads from the patient journal/charts relevant information. (2) Images are loaded and selected to be put onto the projector screens, (3) the patient and the findings are discussed in the group. The discussion is in general involving 2-4 people including the radiologist.

3.2. Findings from the Demo/Focus group

The patient selected by the radiologists was one with substantial image material of several modalities. The patient data was anonymized and transferred in its original DICOM format. The demo of the prototype was an intimate setup at the display wall lab at the computer science department. Present were the design team, the current head of the radiology department, a former head of the radiology, now head of clinical IT-systems at UNN, a visiting senior radiologist and a chief physician at the pathology department. The demo itself was a series of interface examples taking advantage of the large display area. In their comments on the prototype they are generally comparing it to the two-projector setup in Figure 1.

The participants liked the extra space and immediately suggested that patient information and history could be available. They suggested that the display should be divided into three parts, where one of the three could be dedicated patient information, while the two remaining could be used to imaging, as they are today. Figure 2 shows pictures from the demo of our prototype. 2 a) shows a complex of images and image-modalities including pathology 2 b) shows 4 selected images from the image set on the left in the image, where one physician moves closer to study details. One of the main hypothesis before the demonstration of this prototype was that the ability to view more information simultaneously would be the main interest in the large display. This is the reason for stitching many CT and MR images together on the different slides. However, even though facilitating the overview- and detail concept proved to be highly successful among the audience, the displaying of many images at the same time seems to provoke the conception that this is a step backwards – that this is what everyone thought when digital imaging was introduced with PACS some years ago. One of the comments during the demo illustrates this point:

“… historically, in the development of PACS, one thought that one would recreate what we had with analogue x-rays, where we had large displays with many images hanging in a rack. The bigger surface on which to hang images, the better it was – we thought. In the first implementations of PACS they thought that the more images they could view – on as many...
displays as possible, the better. (…) Then the breakthrough came, when someone was thinking simple and noticing that ‘you never look at more than one image at a time. You only need the option of choosing one image out of several and look at that more closely’ ".

Furthermore, one of the participants felt he was “drowning in information” when all the images were sequenced over the entire wall. Another comment was that it could be useful to have certain kinds of information available all the time on the screen (static), while the rest could change. An example of static information was patient information like name, address and which department the patient belonged to.

As for the collaboration aspect of the large display there was a couple of issues that came up during the presentation. One was tied to the fact that the potential “added” information pieces that would be on the wall is not currently shared – or at least not visually with the audiences in such settings. As mentioned before, the textual information, patient history, etc. are currently shared only orally and so the presenter has the possibility of “screening” this information before it reaches the audience (selecting and omitting pieces information as he/she finds relevant). Furthermore, this material is not authored today with visual sharing in mind, and changing this might also change how the content is created. This might for instance mean that whom ever is presenting might use longer time in preparing (and in the first place – writing) this information for presentation. This is, of course, related to how the presentations are prepared today – which needs to be studied. The other related issue was that of floor control: who selects and manipulates the displayed information on the wall? A quote from one of the participants:

“ (…) if you take mammography, for instance – there are three things in use: x-ray images, EPR and pathology. Is it so that one person can control the x-ray images, one can control the EPR and a third can control the pathology? It has to be like that (…)”

The issue of whom and how one controls the presentation and what goes onto the screen is an important one, and a real challenge for the interface design. There were also quite a lot of questions regarding the tiling of the screen and whether this could be better done in a finished system. The audience seemed to agree that the difference in coloring between the projectors would have to be reduced.
4. Conclusions, discussion and further work

Although information overload seems to be the basic concern that is provoked by our prototype, we believe that this issue needs to be counter-balanced by the fact that the large display technology is not - in this context - meant to be used by a single individual alone. The large surface and high resolution provides a novel situation where much more information could be made visible simultaneously. We have experienced that the re-introduction of cascading images on the large display may not be particularly useful, even if it is a tempting way of utilizing the extra display area. Instead, the cues are thus far, that the extra screen real estate should be configured so as to bring more diverse information that facilitates the collaborative problem-solving and - decision making process that clinical conferencing is about – not more of the same information. A consequence of this matter is the problem how to highlight what information is in focus at any time – or how to select or “frame” the relevant information at any time [8]. The first and most obvious thought is to present overview (i.e. a collection of the generally perceived most important, diverse pieces of information on the patient) by default and to enable selection of detail on an ad-hoc basis. The effects of the large, high-resolution displays remains to be seen in real use by clinicians, which we hope to achieve through iterative development of a radiology interface for the wall and subsequent opportunities for clinical testing.

5. Acknowledgements

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6. References