The Leeds Powerwall Project (LEEP)

Roy A. Ruddle
School of Computing
University of Leeds
Leeds LS2 9JT, UK
r.a.ruddle@leeds.ac.uk

Chris Rooney
School of Engineering and Information Sciences
Middlesex University
London, UK
c.rooney@mdx.ac.uk

Jeremy Swann
School of Computing
University of Leeds
Leeds LS2 9JT, UK
sc06jas@leeds.ac.uk

Rebecca Randell
School of Healthcare
University of Leeds
Leeds LS9 7TF, UK
r.randell@leeds.ac.uk

Darren Treanor
Leeds Teaching Hospitals NHS Trust /Leeds Institute of Molecular Medicine
Leeds LS9 7TF, UK
darrentreanor@nhs.net

Phil Quirke
Leeds Institute of Molecular Medicine
University of Leeds
Leeds LS9 7TF, UK
p.quirke@leeds.ac.uk

John H. Hodrien
Faculty of Engineering
University of Leeds
Leeds LS9 7TF, UK
j.h.hodrien@leeds.ac.uk

Rhys G. Thomas
School of Computing
University of Leeds
Leeds LS2 9JT, UK
r.g.thomas@leeds.ac.uk

Abstract
This article summarizes research at Leeds that ranges from investigations of the fundamentals of interaction with Powerwalls, to the design, development and evaluation of real applications. Some of the research has led to the deployment of a Powerwall-based virtual microscope in a large hospital, for the specialists training of histopathologists.

Author Keywords
Wall-sized displays; interface design; evaluation; virtual microscope; digital pathology; visualization; undergraduate education.

ACM Classification Keywords
H.5.2. [Information interfaces and presentation]: User Interfaces – Graphical user interfaces.

Introduction
Powerwalls are large, high-resolution displays, which are ideal for the visualization of huge datasets. The first one (University of Minnesota, 1998) only had 8 million pixels and was driven by Silicon Graphics RealityEngines, but today's Powerwalls can have hundreds of millions of pixels and are driven by a suite of PCs. Powerwalls can have either projected or flat panel displays. The former are seamless, whereas the latter have bezels between the displays but are 10

times cheaper. Experience shows that bezels simply do not matter for many applications.

The Leeds Powerwall Project started in 2006 with the building of a 54-million pixel vertical (Powerwall) display from 28 x 20-inch monitors, and a 23-million pixel horizontal (Powertable) display from 12 monitors (for details of the technical set up and OpenGL middleware, see [3]). In 2010 all of the PCs were upgraded and, funded by the VR Microscope project, two 44-million pixel Powerwalls were installed on the St James' University Hospital site, in the Leeds Institute for Molecular Medicine and the hospital's oncology unit.

Our research ranges from investigations of the fundamentals of interaction with Powerwalls, to the design, development and evaluation of real applications. The research is summarized below.

Fundamentals of Interaction

It is well known that window management and distal access to data are problematic with Powerwalls, and inhibit user interaction [6]. We have addressed this by developing low-precision methods for interaction, which use a transparent Manipulation Layer (window management) and a carefully designed Power-Lens (data selection) [7]. The Manipulation Layer makes window management 25% faster, and the Power Lens speeds up the selection of detailed data by 18%. These are complemented by techniques for grouping and moving sets of windows, preventing windows from overlapping using a ripple metaphor, and running remote applications using VNC. It is worth noting that in all these studies the interface was a mouse and keyboard, which is very effective for interaction on walls of this size.

Current research is developing interfaces to support heterogeneous desktop/Powerwall display collaboration. This is motivated by a geophysics application scenario.

A hallmark of our research is the detailed analysis of participants' interaction behavior, to explain performance differences that are observed and understand how interfaces should be improved. One example comes geographical visualization search tasks, and led to the identification of a specific circumstance under which physical navigation [1] provides a substantial benefit. This circumstance is when a data set can be viewed in its entirety on a display, and the implication is that as soon as virtual navigation is also required the benefit of using a Powerwall to display a single view of a large amount of data largely disappears [8].

Analysis of transport pollution

This research involved a case study that was performed in conjunction with Leeds' Institute for Transport Studies, and involved analyzing traffic, air quality and meteorological data from a main road junction in Headingley, Leeds. Both single-user (a domain expert) and small-group collaborative visualization were evaluated (six domain novices).

The Powerwall proved useful for data validation because physical navigation allowed large time-series to be easily inspected. Group data analysis was helped by the physical size of the display, which facilitated discussion, and the high resolution for showing multiple representations of the data in both detail and context. Usage of a mouse and keyboard proved eminently effective for collaborative data analysis on a wall-sized display.

Visualizing cardiac structures

As part of the Integrative Biology e-Science project, extremely high resolution MRI scans of a rabbit heart were visualized using isosurfacing techniques [2]. By utilising the Powerwall, physiologists could explore the 3D space much more easily than before and analyse fine detail in wider context. This work won the vizNET Showcase 2008 award, and has been featured on the BBC news website, and as a cover story for Physiology News.

The Leeds Virtual Microscope

Our most substantive line of research has been the Leeds Virtual Microscope, which allows histopathologists to diagnose diseases such as cancer from gigantic digital images of human biopsies that have been scanned at magnifications of up to 400×. An enormous volume of data is involved, because a standard-sized (75 × 25 mm) glass microscope slide produces a scanned image that is up to 180,000 × 100,000 pixels in size, a single patient's case can involve more than 100 such slides, and the consultants in a single cancer centre may inspect a quarter of a million slides per year.

So far we have developed three versions of our microscope. The first (see Figure 1) helped to start a debate within pathology about the size of display resolution that would be beneficial in a clinical setting, driven in part by an evaluation which showed that consultant and trainee histopathologists could make diagnoses as fast on a Powerwall version of the microscope than they could with a conventional microscope and glass slides [9]. By comparison, diagnoses take substantially longer on commercially available desktop systems.

The second version of our microscope was implemented on Powerwall and high-resolution (11-million pixel) desktop display. The Powerwall version has been in use since 2010 for the specialist training of histopathologists, and evaluated for the teaching of medical students (see Figure 2) [4]. The desktop version was evaluated for primary diagnosis [5].

Figure 1. Cellular detail on a 20×9mm piece of cancerous tissue, viewed at high magnification with the Leeds Virtual Microscope on a 54-million pixel Powerwall display.

Figure 2. Student asks about features on a slide during a tutorial for undergraduate medical students [4].

The third version of the Leeds Virtual Microscope has been evaluated for primary diagnosis of large cases, and has been successfully tested with terra-pixel (10^{12}) collections of images.

On the wall-sized systems we use a wireless gamepad for interaction. Users learn how to operate the gamepad in a few seconds, and it allows rapid panning and zooming to any part of a virtual slide that is of interest. On the desktop systems we use a mouse and keyboard interface for rapid, flexible navigation.

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