INTERACTIVE POLYMEDIA PIXEL AND PROTOCOL FOR COLLABORATIVE CREATIVE CONTENT GENERATION ON URBAN DIGITAL MEDIA DISPLAYS

Barker, Tom; Haeusler, M. Hank
UrbanAid, University of Technology, Sydney, Australia
Tom.Barker@uts.edu.au, Matthias.Haeusler@uts.edu.au

Beilharz, Kirsty
Sense-Aware Lab, University of Technology, Sydney, Australia
Kirsty.Beilharz@uts.edu.au

Keywords: Urban Design; Outdoor Digital Media; Information Architecture; Multidisciplinary Design; Augmented Reality; Media Facades; Interaction Design; Urban Screens.

Abstract: This research is an investigation into a creative and technical ‘pixel’ element that may facilitate Urban Digital Media, a field that inhabits the intersection between architecture, information and culture in the arena of technology and building. It asks how contemporary requirements of public space in our everyday life, such as adaptability, new modes of communication and transformative environments that offer flexibility for future needs and uses, can be addressed by a new form of public display, assembled through the use of an advanced pixel, described as an interactive Polymedia Pixel with situated media device protocol. The weakness of many current media façades for building-scale interactive installation environments lies in the dearth of quality creative content and unresponsiveness in terms of potential human factors, richness of locative situation and contextual interaction (Sauter, 2004). Media facades have evolved from simple 2D visual displays to 3D voxel arrays for depicting static and moving images with a spatial depth dimension (Haeusler, 2009). As a subsequent step in this development, the research investigates a display that reacts to the need for empathetic and responsive urban digital media; integrates multiple modalities; smart energy-saving; and collaborative community engagement. The Polymedia Pixel, which is presented in its research and development in this paper, contributes to the evolution of building-scale interactive installation environments. The paper firstly discusses the attributes of the Polymedia Pixel in order to address the above mentioned weaknesses of public displays. In responding to these necessities, the prototype of the developed Polymedia Pixel with its technology is outlined. The Polymedia Pixel research aims to address the context of urban media, providing citizens with the means to communicate through pervasive technology and to engage in collaborate creative content generation using a variety of mobile and pervasive devices.

1 INTRODUCTION

Urban Digital Media is a field that inhabits the intersection between architecture, information and culture in the arena of technology and building. It is needs driven: historically, the built environment has been based on centuries-old materials, construction techniques, and static functionality. But contemporary requirements also include adaptability, new modes of communication and transformative environments that offer flexibility for future needs and uses. The term Urban Digital Media embraces a range of technologies that offer to enhance our built environments. These include digital tools, display technologies and networked communications that can transform and augment the constructed reality of a built environment, allowing new forms of intelligent, adaptive, interactive and self-aware information architecture to be developed. Urban Digital Media builds on the increasingly pervasive Internet, mobile computing and communications technologies.

A weakness of many current media façades and building-scale installation environments lies in the dearth of quality creative content and interactive unresponsiveness - ignoring the potential richness of human factors, such as locative situation and contextual engagement.

Media façade have been classified into seven different categories based on the technology used (Haeusler, 2009). In their historical development, when considering LED technology as a medium to communicate, they have grown up as (firstly) a two-dimensional visual display (an extension of the idea of screen), then (secondly) the voxel 3-dimensoinal pixel array for depicting static and moving images with a spatial depth dimension (Haeusler, 2010).

Still there are a number of shortcomings in media façade technology when providing a mechanism for sociable community involvement engendering collective creativity, inventiveness, and a culture of innovation. This paper suggests a way to overcome the above-mentioned shortcomings by introducing the research behind the Polymedia Pixel.

The interactive Polymedia Pixel and situated media device protocol responds to the need for empathetic and responsive urban digital media; to integrate multiple modalities; smart energy-saving; and collaborative community engagement in urban digital media. This extends the idea of the autonomous pixel (programmable and intelligent) with the ability to emit sound as well as light, sensing, receiving messages, and achieving zero energy status. It addresses the context of urban media, providing citizens with the means to communicate through pervasive technology and to engage in collaborate creative content generation using a variety of mobile and pervasive devices.

2 ATTRIBUTES OF THE POLYMEDIA PIXEL

2.1 Pixel Structure

The term 'pixel' refers to the smallest discrete image element, typically on a computer screen. By multiplying up the arrangement of pixels, an image is resolved. The notion of the Polymedia Pixel is an extension of this definition, incorporating multimedia elements into the discrete pixel element. Hence, multiplying up a Polymedia pixel creates not just an image, but also multimedia attributes such as a soundscape, a sensing array, or an interactive field. Furthermore, a Polymedia Pixel is a physical object that can be spatially arranged in multiples in 3D and not just 2D grids. In the 3D configuration, pixels are known as a voxel, a term derived from the computer games industry. The researchers were able to consider the Polymedia Pixel seriously by taking advantage of exponential advances in technology in combination with a multidisciplinary design approach involving designers, architects, sound and media experts – an approach described by Barker and Kokotovich (2010).

The paper firstly presents the following seven attributes of the Polymedia Pixel in order to address the mentioned weaknesses of public displays, namely:

1. **contextual responsiveness** - to *physical, environmental* factors
2. **interactive responsiveness** - to *human* intervention and activity in the proximity
3. **intelligence** - smart controls that can adapt physical behaviour to suit conditions
4. **multimodality** - ability to communicate through non-visual channels, such as sound
5. **sensing and communication** - in order to sense/detect conditions of environment, human interaction and to be accessed by networked mobile devices
6. **energy efficiency** - optimising energy expenditure and capturing self-powering energy sources
7. **open protocol for networked device controllers** to receive communication from a wide variety of devices, enabling public access and interactive content, localised to physical context.

The authors argue that with these seven points a media façade could possibly become more then a display and would open up the possibilities for a new form of engagement with context and space. This engagement could be in the opinion of the authors be of the genus of ADA, an intelligent space presented at the Swiss Expo in 2002, which will be discussed at a later stage when comparing the research with work by others done in the field of enquiry. In particular, pixels and voxels have hitherto been 'deaf'. Our innovation lies in the ability of pixels to sense (gather information/interaction) and to communicate using polymodality: sound as well as visual signals. A second goal is the stackable structure encasing the pixels sp that their formation can be sculptural or distributed and importantly, immersive in scale and form, that is, people can walk amidst the pixels rather than view it only as a mono-dimensional array in human-scale proportion.

2.2 Participatory creative content and protocol

A number of participatory creative projects in urban spaces have demonstrated the excitement, interest and content that can be garnered by involving the community in the experience of its public spaces. The "problem" or constraint of many of these examples is that users must embrace a specific software download, device or site-specific interface in order to interact with the project, e.g. Golan Levin's *Yellowtail* (1998-2000), Lozano Hemmer's *Body Movies* in Rotterdam Square, *Project Blinkenlichten* in Berlin's Alexanderplatz (2001-2002). The Polymedia Pixel proposes an entirely different approach that recognises when a person is in the proximity of an accessible physical display or device with shared control, that invites people to interact using their own device and familiar interface with minimal software downloading.

The idea of collaboratively making music and art, playfully drawing and 'jamming' in an urban environment is a *social* one, a *social network*. Interestingly, however, most social networking platforms, such as FaceBook, Twitter, instant messaging, etc. actually assume that your social network of people is geographically distributed, physically remote, invisible, not able to be conversed with directly, separated by space, culture, anonymity in some cases: potentially, people whom you would never meet in "real" life (i.e. physical experience). In contrast, we are generating a protocol for social connectivity and networked collaboration when multiple users enter the proximity of a shared urban digital media and wish to discover/create together. The people who have access to the device interface are those in range of the visibility, audibility and affect of the pervasive technology.

The protocol will be developed on CNMAT's Open Sound Control (OSC) standard (Freed & Schmeder, 2009) which provides a way to rapidly build ad-hoc encodings for control structure programming and adds a basis for protocols such as TUIO (tangible and multi-touch surface interaction) and GDIF (gestural data interchange).

3 STEPS OF DEVELOPMENT

3.1 First prototype

A first prototype called the *autonomous pixel* (concept and technology patent pending 'Digital Autonomous Pixel' Australian Patent Application TSJ:NMT:P81008.AU / Barker and Haeusler) was developed for the SmartLight Festival 2008 (http://www.smartlightsydney.com/artists/barker-and-haeusler; accessed March 2010), covering some aspects of the above-mentioned attributes.

3.1.1 Prototype Janus Screen

The SmartLight festival was a major component of Vivid Sydney, a new public festival from 26 May – 14 June 2009 held in Sydney, Australia. UrbanAid from UTS Sydney participated in this festival with an installation called the Janus screen.
Here, first principles of the presented research were tested and further developed. The aim was to combine the attributes of the pixel with an interest in complex curved screens (Haeusler, 2009) to generate a screen shaped like a human face to have a maximum number of different curvatures combined in one media façade. The idea of a face-like media façade also assisted in generating meaningful media content for the installation, namely: human expressions. The media content was developed in correspondence with the face shape and collected social data. Internet sites allowing the sharing of social data and images have gained greatly in popularity in recent years. To date, these shared images and communications have been kept on personal displays and did not impact on a public mood in the public space (Barker, Haeusler, 2009).

The project proposes a pixel façade generated from 183 grayscale-controlled light spheres arranged as a giant human face hanging above the street: People could MMS pictures of their faces to it and via a homepage, both accumulating facial expression

– the currently leading (or most relevant) expression then modifies the face which is animated. The name 'Janus screen' was inspired by Janus; the Roman god with two faces, and Greek theatre masks. Through emotional expressions a feedback loop is created between private expression and public image.

3.1.2 Screen Technology

The screen comprised 183 pixels arranged to display the captured expressions. Contrary to conventional screens that display media content on a flat display surface, the 'Janus screen' imitates the complexity and form of a face. In this way, the screen creates a surprise effect in form by being an anamorphic screen, a screen that is only readable from one certain privileged perspective. As previously described, this privileged perspective effect is achieved by positioning the sphere-shaped pixels in the form of a non-standard complex screen. All 183 pixels are positioned within a 3D-matrix with defined distances in X and Y direction. Due to the space between the pixels, a different screen is perceived from each different spatial position. The light points were built of 100mm polycarbonate spheres containing a white LED, a PV cell, a battery and a CPU. The autonomous pixels were attached to each crossing point comprising an acrylic substructure with horizontal and vertical elements.

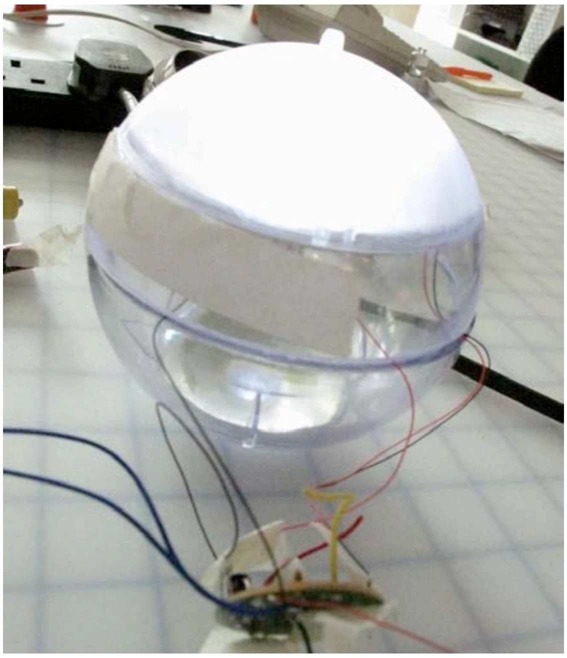

Figure 1: Autonomous Pixel prototype used as the Janus screen. Photo: M Hank Haeusler

3.1.3 Software Screen

The software received information either from the homepage platform provided by the organisers (where participants upload their image) or via images sent as an MMS picture straight to a site. Thus participation before and during the festival was guaranteed as well as via mobile phone in front of the screen. Various face recognition softwares are currently available. They all capture a number of points on a face. These captured expression were used as the input to trigger a pre-recorded video of a face showing the expression previously provided by the participants. The displayed expression stayed for a period of 15 seconds before the screen returned to a 'neutral' expression before starting again with the next expression input.

Figure 2: Face recognition software for Janus screen. Photo: T Barker

The screen itself was installed at the centre of Kendall Lane in The Rocks, Sydney. The location, a lane approximately 80m long, helped to give viewers a clear view of the screen from the entrance to the lane. This was intended to place beholders into a privileged position when first viewing the

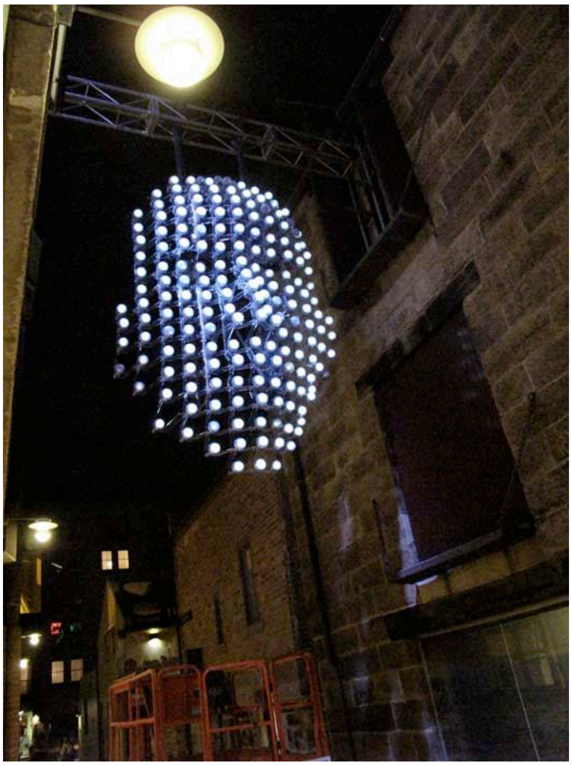

Figure 3: Views of the Janus Screen at the SmartLight Festival in Sydney May – June 2008. Photo: T Barker

installation and allowing them to experience the effect of an anamorphic screen when walking along the lane. The further they walked, the more distorted it became. Directly underneath the screen it was no longer to understand or see the image at all.

At this first stage, not all aspirations of the Polymedia Pixel could be fulfilled due to cost and time constraints. Nonetheless, the installation did cover most of the aspects realistically achievable in a 3-month developing, designing, testing and building period. The screen achieved an anamorphic effect and through the built-in PV cells was independent of any power supply. At this early stage, it was not yet possible to embed wireless communication into the individual spheres.

3.2 Second step

Based on this first step the research intent is to develop the system further and provide the functionality of the seven Polymedia Pixel attributes: contextual responsiveness; interactive responsiveness, intelligence; multimodality; sensing and communication; energy efficiency; open protocol for networked device controllers.

For the next stage, the following hardware system elements were chosen to create the anatomy of a Polymedia Pixel: (1) LED – light emitting diode - for producing the image; (2) Speaker for transmitting sound; (3) PV cell with rechargeable battery for energy production and storage; (4) Photo-sensor/camera to react to its environment; (5) Microprocessor to process data and information; (6) Microphone to record sound; (7) Cable network or wireless WiFi to transmit data; (8) Robust weatherproof casing for Urban Digital Media applications.

The arrangement of microprocessors and network to achieve this functionality was a critical choice. The first implementation uses 1000 Polymedia Pixels and, given that the system is a development platform for research and education, these units needed flexibility and the option of upgradability. Because of dramatic falls in hardware costs, it is possible to put a networked 170x170mm Mini-ITX - a fully functional $120 PC - into each Polymedia Pixel. These can then optionally be enhanced with phidgets (http://www.phidgets.com; accessed March 2010) or similar devices as necessary, although the basic unit comprises each of the 6 hardware elements. A custom board with USB interface deals incorporates the functions of LED lighting and photosensing. Each Polymedia pixel is contained within a 250mm diameter faceted spherical volume. The casing diffuses light to allow the surface to be evenly illuminated by the LED. Each Polymedia Pixel runs the software application Processing (http://processing.org) on Linux OS, resident on a flash RAM. Through simple use of shared memory, the Polymedia Pixels can operate as a grid farm, neural net, or traditional networked system. The final component is a photovoltaic solar cell and rechargeable battery solar cell. This is supplemented with a power supply for indoor applications.

The control protocol includes CNMAT's Open Sound Control (OSC) standard (Freed & Schmeder, 2009) which provides a way to rapidly build ad-hoc encodings for control structure programming and adds a basis for protocols such as TUIO (tangible and multi-touch surface interaction) and GDIF (gestural data interchange).

4 WORK BY OTHERS

The paper has listed above a recent example of an interactive space or a space altered through interactive media content: "Ada – the intelligent space", an interactive pavilion at the Swiss National

Exhibition Expo.02 designed by the Institute of Neuroinformatics, a research institute at the University and ETH Zurich. Ada is an open system based on achievements of neuroscience. Similar to human – and in contrast to the conventional computer – Ada can process erroneous and imprecise information. Ada has the ability to direct her attention to a person or group of persons and play with them.

Unlike conventional computer systems based on rules, she consists of a neural network modelled on nervous systems. Ada is able to learn but is also ”unpredictable”, and her way of reacting to her environment is analogous to human emotional behaviour. Ada can coordinate her individual components and employ them in a goal-directed way.

Ada is described on the exhibitor’s home page as follows (www.ada-austellung.ch; accessed February 2006):
"Ada is a novel artificial organism, a creature in the shape of a space that can perceive and react to its surroundings. At the same time, her form facilitates a novel interaction between humans and machine that goes beyond the possibilities offered by a conventional computer, such as keyboard, mouse or joystick. Ada has sensory organs. She can see, hear and sense touch and contact. While Ada cannot communicate with words, she expresses herself through sounds, light and projections. Ada likewise learns how to synchronise her various components, such as the floor plates, the movable eyes and the light fingers. Ada is able to remember the visitors with whom she has played and whose gestures, movements and sounds she has observed. Like humans, Ada learns from experience: she can store an incident and later build upon it. Ada can furthermore link various pieces of information and draw conclusions from this. Upon observing two individuals standing close together for a long period of time, she concludes that they are a pair."

There are a number of other projects that deal with interactive spaces and/or intelligent rooms such as MIT's intelligent room project or the intelligent space project pursued at the University of Tokyo. However, both these projects are rather utilitarian in the interactive technology they apply, whereas as an affective-cognitive space Ada is currently unique.

Figure 4: Image of ADA www.ada-austellung.ch

So what are the genus similarities with the research presented in the paper?
The authors see two points listed in the quote above where the proposed system can possibly overlap with interests of Ada. These assumptions are based on having in both, Ada and a possible set up with the Polymedia Pixel, a similar neural network modelled on nervous systems. For us both systems have “sensory organs”. The quote above listed that Ada “can see, hear and sense touch and contact” and then “expresses herself through sounds, light and projections”. These two observations also form the principles for the Polymedia Pixel. Where as in Ada, as seen in Figure 4, the “sensory organs” are located in traditional spatial arrangements such as walls, floors and ceiling the Polymedia Pixel allows to define space through arraying them in a spatial manner.

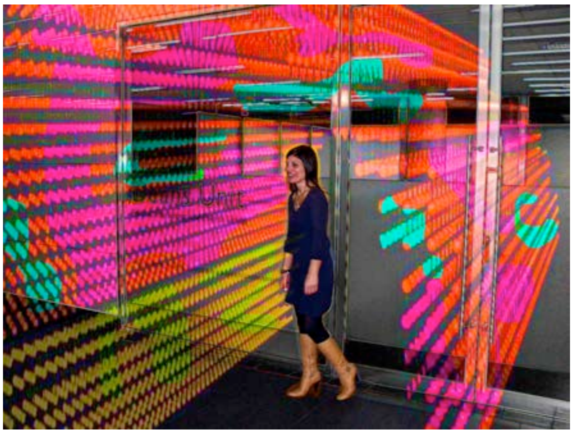

Figure 5: Arrangement of Polymedia Pixel to define space

These criteria also form the basis for evaluation of the interactive Polymedia Pixel's technology,

together with user-experience evaluation to measure:
(a) responsiveness of the system to human intervention;
(b) the user-experience of collaborative creativity; and
(c) usability of the situated media device interaction protocol as a 'push' technology that delivers controls in the familiar device OS GUI (for example in Apple iPhone's SDK most applications share the Cocoa-based controls, meaning that multi-touch gestures, sliders, buttons, dragging, etc. have consistent appearance and behaviours across all iPhone OS applications).

5 CONCLUSIONS

Although the second step of development is in progress, the work so far indicates that there is a great deal of further research potential for volumetric pixel applications with interactivity. The Polymedia Pixel constitutes an ideal platform for combined education and research and will be evaluated during 2010, following the current hardware and packaging development phase.

It is interesting to note that the 'Poly' aspect of this project has emerged from a multidisciplinary team working in a collaborative way, with fast track development. The mixture of disciplines involving designers, architects, sound and media experts is resulting in a richer format for the Polymedia Pixel. Finally, although many of the components of the Polymedia Pixel are standard – deliberately, to keep costs down and flexibility up – the combination of these into a giant array of very large physical cells (250mm diameter), with distributed onboard sensing and control is novel. This system can host Urban Digital Media applications with 2D/3D immersive engagement.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the University of Technology, Sydney in funding this research through a Faculty of Design, Architecture and Building [DAB] CapEx grant, Australian Research Council Discovery Project DP0773107 and Early Career Researcher grant. As well we would like to acknowledge Sam Fergusson (Sense-Aware Lab) and Jon Sawdon Smith, both team members of the current research project. Furthermore we acknowledge the work of Mona Lieb, Frank Maguire and Jason McDermott on the Janus Screen. Parts of the text explaining the Janus Screen have been previously published in Urban Screens Reader edited by Scott McQuire, Meredith Martin and Sabine Niederer; Institute of Network Cultures, Amsterdam 2009. The research is a project of the SIM research node (Situation, Interactivity, Media) at CCDP (Centre of Contemporary Design Practice) UTS Sydney.

REFERENCES

Barker T, Haeusler H, Maguire F, McDermott J. Politics and Demographic, Questions of Crowd Based Interface and Polling, OZCHI 2009, Melbourne, Australia

Barker T, Kokotovich V. Technological change: moving forward together. CDVE2010, Mallorca, Spain.

Beilharz, K. and Ferguson, S., "Aesthetic Sonification Toolkit for Real-time Interaction with Data," in *Proceedings of the Hawaii International Conference on Arts and Humanities*, Hawaii, USA, 2009.

Freed, A. and Schmeder, A. "Features and Future of Open Sound Control version 1.1 for NIME," in *New Interfaces for Musical Expression (NIME09)*, Pittsburgh, PA, 2009.

Haeusler, M. Hank *Media facades – History, Technology, Content*, avedition, Ludwigsburg 2009.

Haeusler, M. Hank *Chromatophoric Architecture*, Jovis publisher 2010.

Kaltenbrunner, M., Bovermann, T., Bencina, R. and Costanza, E. TUIO: A protocol for table-top tangible user interfaces *6th International Workshop on Gesture in Human-Computer Interaction and Simulation*, 2005.

Levin, Golan *Yellowtail* (1998-2000) interactive software system for the gestural creation and performance of real-time abstract animation: http://flong.com/projects/yellowtail/ (accessed September 2009.

Philip, R.C., Michael, J., David, et al. "QuickSet: multimodal interaction for distributed applications," in *Proceedings of the fifth ACM international conference on Multimedia* Seattle, Washington, United States: ACM, 1997.

Saffer, D: 2007, Designing for Interaction: Creating Smart Applications and Clever Devices, New Riders.

Sauter, Joachim, "Das vierte Format; Die Fassade als mediale Haut der Architektur", Fleischmann, Monika; Renhard, Ulrike (Eds), *Digitale Transformationen. Medienkunst als Schnittstelle von Kunst, Wissenschaft, Wirtschaft und Gesellschaft*, (Heidelberg: whois verlags und vertriebsgesellschaft, 2004).