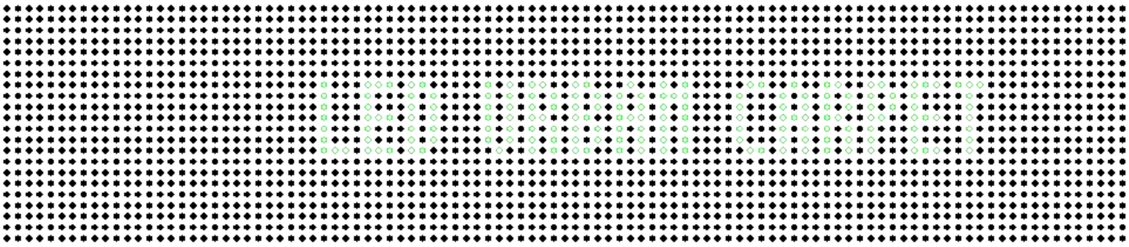

LED-s URBAN CARPET:

A PORTABLE INTERACTIVE INSTALLATION FOR URBAN ENVIRONMENTS

by

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ABSTRACT

The aim of this paper project is to generate a new kind of physical scenario where people can interact by means of technology with the urban and social environment. This paper suggests that introducing a new kind technological interactive platform, in this case a LED-s Urban Carpet, in a public space could enhance social awareness and interaction between people nearby.

In order to achieve the paper goal, a theoretical framework for understanding and designing interactive computing systems to be embedded in an urban landscape is developed. Also, the experiences in building and field testing the LED-s Urban Carpet prototype in three different urban locations in the heritage city of Bath are reported. Initial findings about how people move, congregate and socialize around the interactive installation are presented, and the levels and types of interaction around the installation as well. In addition, some social factors that can cause embarrassment or that can inspire social interaction around the public display are explored. The design and test of the LED-s Urban Carpet is evaluated in relation with the theoretical background. Finally suggestions are made for improve the prototype and develop further systems. This project was partially funded by MSc. Adaptive Architecture and Computation and Cityware: a research project funded by the EPSRC, UK.

Key Words: Interactive installation, socializing interface, urban computing, tangible technologies, body interfaces, LED display.

Word Count: 11.498

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1. INTRODUCTION

Technology has moving beyond the traditional industrial, workspace and research environments, embedding in portable and easy to manage devices which have become essential components of our daily routine. Nowadays, we cannot conceive of our life without those digital and small devices, penetrating in every aspect and scenarios where our routines lapse. In addition, the rise of new means of technology opens new forms of their embodiment in space, both virtual and physical ones. This paper concerns, is related with the manner in which technology have cross the gap between be embedded in a virtual space to a more tangible and human perceptible one, and how become to be introduced in our daily architectural environment.

Since the beginning of the 1990s, Virtual Reality (VR) has represented one of the well-known fields, which develop technology in relation to computing and an architectural environment. However, the high technology level, the restrictions of a PC-based work place, the high cost of its implementation, and the completely immersive scenario provided have constrained its usage to a more academic and research background [Penn et al., 2004]. Yet, new approaches have emerged, and computing has moved beyond the Graphical User Interface (GUI) and the usage of desktops and laptops.

A new kind of relationship between digital computing and the physical environment can be considered under the term Mixed Reality Architecture (MRA), which is about the integration of digital information in a real world scenario, combining the virtual with real in such a way that digital information appears to be attached to physical objects [Schnadelbach et al., 2003]. On the other hand, technology is slowly disappearing in the surroundings, becoming calm and ubiquitous. The era of Ubiquitous Computing addresses the idea of a world in which computing is embedded into the environment and is imperceptibly integrated into everyday things. As Mark Weiser states [1991], Ubiquitous Computing is an age in which technology recedes into the background of our lives as embedded digital devices like Tabs, Pads and Boards along with the infrastructure, which allow these devices to talk with each other and have accessible information and communication everywhere at anytime.

All these new approaches bring the challenge of developing novel computing interfaces that can be embedded into existing or new architectural and physical environments. They extend the use of these interfaces to our homes, classrooms, offices and meeting places as well as to public spaces that form the urban technological landscapes of a living city.

1.1 URBAN ENVIRONMENT, TECHNOLOGY AND SOCIAL INTERACTION

Urban landscapes are not only important because people spend a significant amount of time in such spaces; they also contribute to our own formulation of identity, community, and self. Much of the richness of life lapses within our own urban settings. While the city is a scenario for work, commerce and business, it is also a place where social life takes place. In the urban space people play, eat, drink, dance, meet friends or just hang out. The built environment is the framework where our cultures develop and transmit; because space regulates the encounter or no-encounter among people and creates multiple states of co-presence that produce innovative social forms, as communities and organisational structures [Hillier & Hanson, 1984]. Architecture is the main support of social relations, because through it the rules and norms of social interaction are expressed, shaped and reproduced.

In that regard, the introduction of physical computing technology into an architectural and urban environment can afford new ways of experiencing the city, community and neighbourhoods. The creation of new kinds of technological platforms will probably provoke new types of social encounters, social interactions between people as well as interactions between people and the physical environment. Thus, new approaches for understanding social interaction patterns will emerge.

Traditionally, architecture has been thought of as static walls, roofs and floors that enclose us. Nowadays, the introduction of technology in the physical space shifts the traditional concept of architecture and invites us to consider architecture as a dynamic and adaptive surface that is sensitive to the surrounding environment, human movements, sound, smells, temperatures or radio waves. Interactive architecture encourages users to be an active performer in the construction of their own environments. It also promotes architecture as a framework to animate these new experiences.

In an attempt to take a step towards that direction, this research project investigates the levels of engagement between inhabitants and dwellers that share the same public or urban space when new kinds of technologies are introduced within the physical space. In many societies, communication between strangers in a public space is rare; people tend to keep to themselves and seem afraid to contact others [Hansson & Skog, 2001]. Also, portable devices, like mobile phones, PDAs, MP3 players and video games, tend to facilitate this immersive behaviour when people use them in a public context. As users interact directly with their electrical devices, they relegate what occurs around them to a second level, which decreases the opportunity to generate spontaneous social interaction in public and urban contexts.

The ambition of this project is to generate an interactive installation to be displayed in the background of an architectural public space. The paper suggests that introducing a certain kind of technological display in a social scenario can enrich the casual interaction of people nearby and can enhance social awareness and engagement. The architectural and public dimensions of this project are important, as it moves computing towards a daily human activity and well-known scenario for most of people. This project aims to support social encounters between people, friends, family and even strangers, by means of a computer-augmented display, which attempt to involve the public constantly to interact and play with it in a way that 1) generates a platform for socializing between users, and 2) forms the backdrop for physical support and a scenario for the emerging experience.

"Those of us who are concerned with buildings tend to forget too easily that all the life and soul of a place, all of our experiences there, depends not simply on the physical environment, but on the patterns of events which we experience there." [Alexander, 1979]

In the next section, the paper describes the main purpose and objectives of this research. After that, section 3 presents a theoretical framework and related projects in relation to the subject under discussion: interactive displays introduced in an urban context. It also presents a list of premises taken from previous work, which are considered during design and building of the test model. In section four, the paper provides a brief description of the process of building of the display, and then illustrates some initial findings from the prototype field trial in the city of Bath. The paper concludes with a discussion of the main findings, the advantages and disadvantages of the methodology, and some key issues concerned with possible future work.

2. RESEARCH OBJECTIVES

The paper is concerned with the design of an urban display and inviting social interaction with the interface and between people acquainted with each other, strangers and observers. The goal of the prototype is to create a novel urban experience, which can be tested in many different social scenarios and locations, in order to achieve a vast range of information related to the subjects under study. This experience will bring a deep understanding of the main factors involved in interactive architectural projects.

This project forms part of Cityware, an ongoing research project developed by the VR Centre, Space Syntax Laboratory and the Centre for Sustainable heritage at Bartlett College (UCL), in collaboration with the University of Bath Departments of Computer Science and Psychology, Imperial College London and HP Labs Bristol, Nokia, Vodafone, IBM and Node Ltd. The aim of the Cityware project is to achieve a better understanding of the urban landscape augmented with the digital landscape of a city, by providing tools, methods and a theoretical framework for designing pervasive systems as an integral part of the urban landscape. [Fatah gen. Schieck, et al., 2005].

The city of Bath is the scenario selected by the Cityware project to investigate the use and impact of new pervasive technologies in contemporary societies. On the one hand, this city is one of the major tourist places in England; on the other hand, it is a UNESCO heritage site that presents constraints to the introduction of new technologies in the architectural background. Finally, the city centre of Bath is enclosed in size, thus making it manageable and more comprehensible while studying and experimenting within its urban environment.

Figure 1, City of Bath, photos by the author.

3. THEORETICAL FRAMEWORK

This section illustrates concepts related to applying technology to everyday physical objects and architectural environments. Also, it lends an understanding of how technological interfaces play a major role as a medium to enhance collaborative work, social awareness, and interaction between users, mostly in organizations and work atmospheres.

3.1 TANGIBLE AND SOCIAL COMPUTING

Making digital bits tangible has been the position of the MIT Media Laboratory, while the “Tangible Bits” concept was developed by Hiroshi Ishii [1998]. This concept aims to allow humans to grasp and manipulate bits by coupling them with everyday physical objects and to be aware of background bits by using ambient display media such as light, sound, airflow and water movement in an augmented space. According to Hiroshi Ishii, the interaction between people and cyberspace has been confined to a traditional GUI, which is separated from the ordinary physical environment where we live and interact. He suggests that through Tangible Bits it is possible to bridge the gaps between both cyberspace and the physical environment.

A different paradigm presented by Mark Weiser [1995] is “Ubiquitous Computing”, which is significant in the way it addresses the idea of a world in which computing is embedded into the environment, but also imperceptible in the way it is integrated in everyday life. In other words, Weiser proposes to export the traditional GUI-style to large and small computer terminals situated in the physical environment. More closely related to this paper is the perspective that urban space is the “Urban Computing” (UbiComp) concept, which is based on Ubiquitous Computing knowledge. This concept focuses on understanding the technological effects of the urban landscape and urban life, and on the adoption of new mobile technologies such as Bluetooth mobile devices and its widespread influence across growing urban landscapes [Paulos et al., 2004].

Another approach developed by the Mobile Bristol group is “Mediascapes” or “Digital Landscapes”. This approach proposes that digital content and computer applications can be overlaid with the physical environment, and people can access that digital media when they walk through locations carrying a mobile device such as a phone, a Global Position Scanner (GPS), a handheld computer or a Personal Digital Assistant (PDA). [Reid et al., 2005]. The use of urban space as the main scenario for interaction between people and technology and the premise that interaction mechanisms are often through body movement or gesture rather than using a mouse or keyboard present an interesting point of view.

The concept of “Mediascapes”, or the creation of digital urban landscapes, may best represent the aim of this project, because it focuses on the interaction of the user who triggers the digital information situated in an existing urban space. Based on the experience of the previously mentioned research groups that developed interactive projects displayed in social environments, some relevant points are presented in the next section and are helpful to take into consideration and implement while designing an interactive augmented system.

3.2 INTERACTION AROUND PUBLIC AND LARGE DISPLAYS

- Participation and engagement of the public: As Harry Brignull and Yvonne Rogers from the Interactive Lab at the University of Sussex argue from their research, the key concern of large display projects placed in public environments is *the "resistance of the public to participate"* [2002, p.1]. For these researchers, the main reason is due to the prominence of the affective aspect of the user experience; in particular, a feeling of social embarrassment often acts as a barrier to interact with a public display in front of an audience. Other authors, such as Churchill et al. found that their users needed *"constant encouragement and demonstration"* [2003, p.6] to interact with the public display; and Agamanolis found that *"half of the battle in designing an interactive situated [sic] or public display is designing how the display will invite that interaction"* [2002, p.4]. Some recommendations from Harry Brignull and Yvonne Rogers, are that the public display has to present a non complicated interactive interface, and without an obligation to take part.

- The prototype and environmental affordance: According to William Gaver from the Interaction Design Research Studio at The Royal College of Art, the affordance of the environment affects how people interact*, "when affordances are perceptible, they offer a direct link between perception and action; hidden and false affordance lead to mistakes"* [1991, p.4]. In other words, the characteristics of the space where the public display is set (accessibility, visibility, conformability, etc), directly impact in the way it is used. Moreover, the affordance of the designed object, in other words, the physical properties of the technological display, have profound effects on the way it is used, as well. Hence, social behaviour should be understood as embedded in and shaped by its material context. And our purpose is to understand how the space is shaped and influenced when incorporated with technology.

- Vertical-based versus horizontal-based displays: there must be a big difference using interactive vertical-based versus horizontal-based or even ground-based displays, because the physical affordance of the displays encourage different social affordances. Yvonne Rogers and Sian Lindley's [2003] research shows that horizontal table displays encourage a group to switch more roles, explore more ideas and follow more closely what each other does. In contrast, people found collaboration around a wall display socially awkward.

- Social Protocol: Mobile Bristol group argued that with any kind of experience there is a "Social Protocol" of engagement, something that people need to know in advance in order to know how to act and behave. For that reason, for the research group the rules of the installation and what to do must be explained to the audience through films, posters or messages [Reid et al., 2005, p.16].

- System Cognition: During this familiarisation period, the user will be concentrating on understanding how the prototype systems work and what they are supposed to do while trying to achieve mastery of the controls, in other words a "System Cognition" model of the interface.

In sum, it seems that enticing members of the public or passers-by to voluntary and spontaneously interact with a display is a major challenge. For us as designers, it is easy to imagine that people will simply walk over to the installation and use it. But, normally what happens is the contrary when people become aware that others can see what they are doing with the display. This awareness produces an inhibiting effect on the user. In the next section related projects that have succeeded in getting people to congregate around and interact with a display are reviewed.

3.3 RELATED PROJECTS

Resent research has addressed some aspects of augmented systems introduced in physical environments. But, most of them have been developed for workspace atmospheres, such as "Hello Wall" [Streitz et al., 2003], or "Wallmap" [McCarthy, 2002], which are vertical displays located in an open area in the workspace, in order to create opportunities for informal interactions and communication. Other cases of large interactive systems, such as "The Opinionizer system" [Brignull, H., & Rodgers, Y., 2003] and "Dynamo" [Izadi et al., 2003], have been introduced into social settings as a common room of a high school and for social gatherings with the aim to extend existing activities and practices or to help people to initiate a conversation with people standing beside them. However, a few of these projects have been designed for outdoor display in an urban and public environment, taking into account the challenges to projects of this nature.

In relation to projects developed in urban environments, the Mobile Bristol group developed a range of outdoor situated "Mediascape" experiences, such as "Riot! 1831", "The BBC's Bristol Mobile Nature Application" or "A Walk in the Woods" [Reid et al., 2005]. Also, the Equator research group produced a range of urban experiences such as "Can you see me now?" or "Uncle Roy All Around You", which explores new kinds of performances, a sort of game taking place on the streets of cities and on-line, mixing digital content with live action [Source: http://www.equator.ac.uk/]. However, in both proposals, the user or player has to carry portable devices to trigger the digital media or connect on-line. Contrary to that approach, the interest of the project presented in this paper is that the body movement and gestures of the user could activate the digital media, creating a direct relation between the human body and the technology interface.

Projects of this nature have been developed, but more as artist installations rather than with a research purpose. Three projects presented below are analyzed through the multimedia content presented on their web pages, because the authors did not develop a comprehensive analysis about how people interact with the large public installations. This lack on information highlights the precarious development of research and investigation in this field.

The Mexican-Canadian artist Rafael Lozano-Hemmer developed a series of «Relational Architecture» installations. These interactive interventions explore the intersection between new technologies, public space and performance art.

The **"Urban Scan" [Lozano-Hemmer, 2005]** project is a large-scale interactive installation where passers-by interact with portraits projected within their shadows on the ground. When people walk around the area, their shadow will be cast on the floor, revealing the video-portrait of local people (Source:http://www.fundacion.telefonica.com/at/rlh//eprlh.html).

This project is innovative in the way it uses the ground and the shadow of people to display digital movie-images, making the display flexible for installing in urban areas without the need of the vertical surface (façade) of a private or public building. Also, the ground-based display did not interrupt the fluent movement of pedestrians on the area. However, people's interaction is based on the relation between the user and the interface (user – display), and it did not encourage interaction among people.

Figure 2, "Urban Scan", www.fundacion.telefonica.com

Another project from the same author is **"Body Movies" [Lozano-Hemmer, 2001]**, which is an architectural installation, displayed on the façade of an existing building, where thousands of portraits are projected on a giant screen. When people cross the square, their shadows appear on the screen and the portraits are revealed within

them. The shadows and portraits generate a play of reverse puppetry and embodied representation. Silhouettes measure between 2 and 30 metres high, depending on how far participants are from the screen.

[Source: http://www.fundacion.telefonica.com/at/rlh//eproyecto.html]

In this example, even though the purpose of the artist was not to enhance interaction between strangers, emergent behaviour of this nature was generated between strangers, friends and families, who collaborated together in order to produce funny and eye-catching shadows projected on the building façade. In this case, the interaction is in relation to the screen (user – display – user) and did not encourage people socializing or exchanging comments. One reason for this lack of direct person-to-person interaction was the large size of the public area. While the screen demonstrated interaction between silhouettes, the extended physical space between the people projecting their shadows prevents socializing.

Figure 3"Body Movies", www.fundacion.telefonica.com

The last example is an interactive communication network formed by modular installations situated in a Subway Station in Sao Paulo, Brazil. The "Idades" project [A. Urquijo ,C. Padilla, D. Desiderio, J. Puig Vilà, P. Morris, 2004] was designed to encourage communication among individuals who share transit and terminal spaces. The spectator can recognize his or her simulated silhouette projected on a screen, which is placed in the middle of the space. It responds to their corporal movements and gestures. Passers-by find themselves involved in a ballgame, which is activated by the silhouettes of those who enter the camera's field of vision. [Source: http://www.idades.org/]

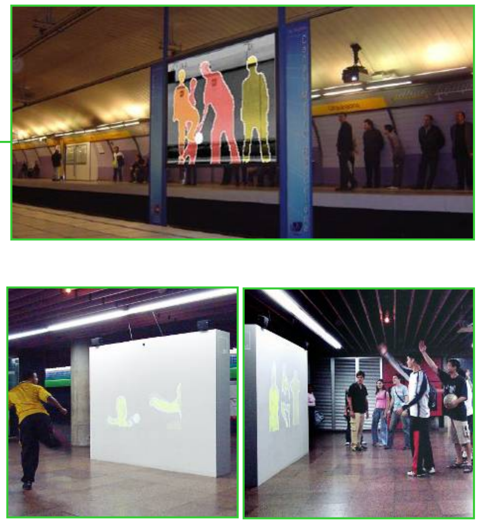


Figure 4, "Idades", www.idades.org

Different from the other two projects, the enclosed size of the display modules and transit area, which surround the screen, allowed social interaction between people, either interaction with the display (user – display – user) or a direct relationship between individuals (user – user). This project is also novel in the way it incorporates cultural aspects to its performance, using a ball and encouraging people to play with it as a football game, what is very attractive for Brazilian people. The game aspect of the last two projects enhances public interest and brings a dimension of play and fun to a public situation. Moreover, complex and unpredictable results evolved when more than one user interacts with the installation at the same time.

From the projects reviewed above, the following issues are directly related to this paper and have been taking into account during the design of the interactive prototype:

- In order to test the installation in different social and physical environments and to take into consideration the heritage properties of the city, the prototype should have the ability to be portable, flexible and rapidly displayed.
- Because of multiple locations, a ground-based installation could be the best alternative in order to enable the fluent movement of passers-by, people's encounters and socialization, as well as many other activities that take place in an urban context.
- A ground-based prototype could make it possible to display a large installation at the level of pedestrian flow in different scenarios and not have problems with the façade of perimeter buildings, such as stores, window displays, pedestrians or garage entrances.
- It is possible that the proportion of the installation to the dimensions of the urban environment might have a direct impact on the social interaction and the level of engagement and attraction that the prototype causes passers-by. First, it appears necessary to leave sufficient free space at the perimeter of the installation in order to give people the opportunity to be an observer or an active participant. Second, people's awareness needs to be considered so that they have enough time to understand and engage with the technological interface. Finally, the familiarity gained by people decreases the chances of their feeling embarrassed in a public arena.
- A recreational interface or a game seems to be an attractive and enjoyable exhibit in public and social atmospheres.
- The social protocol of engagement must be easy to accomplish in order to avoid explanations on how to behave and avoid embarrassment and awkwardness.
- The engagement procedure, how to interact with the prototype and how it works, must be understood by the user without difficulty, in order to enhance spontaneous interaction and avoid complexity.
- Another consideration is that people can leave or integrate without disrupting the ongoing collaborative activity.
- Finally, in relation to the design of the display, one recommendation could be the introduction of novel and attractive factors to draw users in. But, it could be a solution that only catches participants for a short period of time.

4. METHODOLOGY

The project is conceived as an urban installation in the form of a carpet of lights. The LED Urban Carpet is GUI of an implicit rather than traditional nature. The latter is almost entirely confined to conventional PCs. This prototype shows information via a changing dynamic of patterns of lights and illuminating a carpet element with the aim of enhancing a person-to-person interactive game. A sort of game was proposed as a nice interface to attract the attention of the public and for engaging them to interact with the display. In this scenario, the viewer becomes a participant that influences the process and system of the installation, which performs differently according to the location of one or more participants.

The installation is designed to take into consideration the nature of the city where it is located, Bath, a World Heritage Site. It is therefore conceived as a portable technological urban display, which does not modify the physical conditions of the urban context where it is located. Because of that, it was also possible to test the installation in order to expose the prototype to a range of diverse scenarios: social environments and physical and weather conditions. In addition, a vast amount of data was collected that was related to this research.

The whole process of manufacturing and testing the prototype is described in the next section. A range of empirical observation methods that are used widely in urban and ethnography studies were employed, including the observation of static activities, local movement and focusing on the social patterns of behaviour and the interaction that occurs in three Bath locations. The target of the study was to examine, by these methods, the adoption and social effects when technology is introduced into an established setting.

The next section presents and discusses public reaction to the LED Urban Carpet: how the installation is used, the emergence of social behaviours around the display, and the impact and modification to the normal use of the space when the prototype was introduced. Also, people were invited to answer a questionnaire to express their personal opinion about the interactive installation. The questionnaire provides critical feedback based on people's judgement and a point of comparison with the research aims.

4.1 BUILDING THE PROTOTYPE

HOW IS THE ARCHITECTURE OF AN INTERACTIVE DISPLAY?

“Interaction” in physical computing can be understood as an iterative process of listening (inputs), thinking (processing) and speaking (outputs). Input and output are the physical parts of physical computing. The programming part requires a computer to read the input, make decisions based on the changes it reads, and activate outputs or send messages to other computers. [O’Sullivan & Igoe, 2004]

4.2 COMPONENTS OF AN INTERACTIVE INSTALLATION

- Sensors are the key hardware for interactive installations because they are the link between people and the computer system. Sensors can measure physical quantities like pressure, light, sound, heat and electromagnetism. User interaction with a sensor produces a sensor signal or trigger signal, which is the input to the computer control. The control computer determines output actions depending on the messages received from the different sensors. The program specifies what digital media are involved (images, sound, lights, etc) and how the installation has to process and display the digital data (screen, projectors, loudspeaker, lights, etc.). The more common sensors used in interactive installations are: pressure sensors, pressure mats and pads on the floor, light sensors, sound sensors, proximity sensors, motion sensors and also mobile devices that can be used to trigger digital media such as: GPS, PDAs, Bluetooth, mobiles phones, etc.

- A microcontroller is a very small and simple computer that has three functions: receiving information from sensors, controlling devices that create physical change and sending information to computers and other devices such as: Basic Stamp, BX-24, PIC chips, Atmel chips, Arduino I/O board and Wiring I/O, among others.

- A networking ability is necessary when the size of the installation needs it, because it allows the use of two or more computers simultaneously and increases the processing power of the programmes. Also, networks enable an application to communicate with other applications or with a server.

4.3 HOW IS THE ARCHITECTURE OF THE "LED-S URBAN CARPET?

The LED-s Urban Carpet consists of a grid of light-emitting diodes (LED-s), which interact with pedestrians by tracking their paths over the grid. The lights will turn on or off depending on a computer program, which defines the behaviour of each light at every instant. The program also defines the rules of interaction between people and lights. The program, which controls the LED-s, is written using a Boid algorithm with the purpose of changing the state of lights to simulate a flock of seagulls that follow the pedestrian. It gives the whole experience a recreational and fun atmosphere.

The location of each pedestrian over the carpet is recognized by pressure pad sensors, which are located in an electronic grid behind the carpet of lights. Both the LED and pressure pad layers form a unit that sends input to the computational program and receives output.

The LED-s Urban Carpet is controlled by three main computational programs, two of them control the input and output boards (microcontroller), in this case Arduino boards; and the other one is the main program which receives the inputs and send outputs according to Boid's program written in Processing.

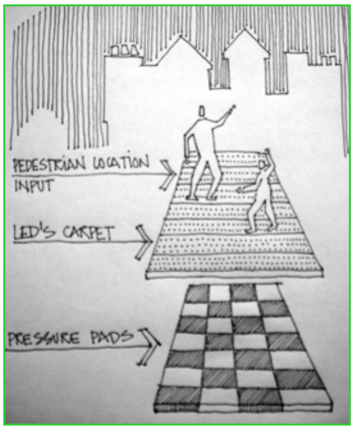


Figure 5, Interactive system draft, by the author.

Processing is an open source programming language and environment, initiated by Ben Fry (Brad Institute) and Casey Reas (UCLA Design, Media Arts). This program is ideal for designers or artists who want to create multimedia content such as images, animations, sounds, interactive programs, etc. The Processing environment is written in Java. With Processing, there is a worldwide community of people developing the program, creating libraries and teaching it as an application tool in art and design schools. Within this community, it is possible to find the Arduino project. [Source:www.processing.org]

Arduino is an open-source physical computing platform based on a simple I/O board and a development environment that implements the Processing language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on a computer (e.g. Flash, Processing, or MaxMSP). Programming the Arduino board requires the Arduino IDE (integrated development environment), which is a derivation of the Processing programming language. Therefore, the LED-s Urban Carpet is controlled by programs, sharing the same language and community environment. These characteristics were the main reasons for choose this technology to build the prototype. [Source: www.arduino.cc]

INPUT / FIRST CARPET LAYER: pressure pad sensors grid

Pedestrians walk over the LED Carpet. PRESURES PAD sensors recognize the location of each pedestrian and send the information as DIGITAL INPUTS to ARDUINO BOARD 1.

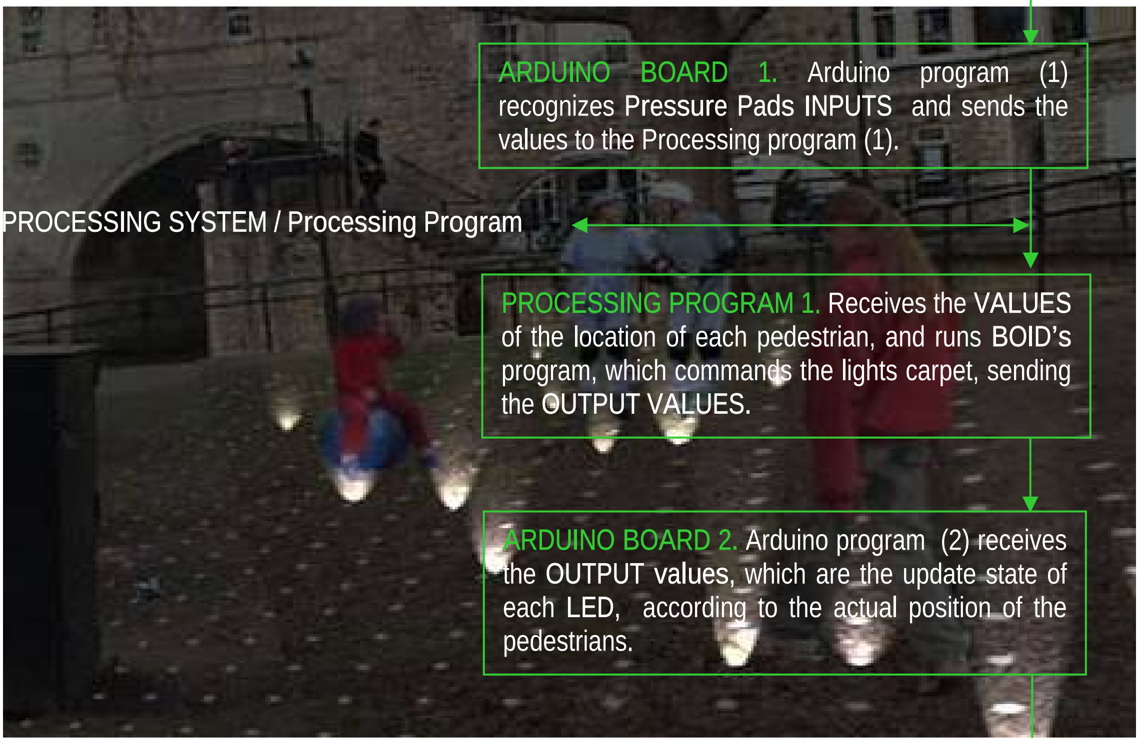


Figure 6, Interactive system software diagram, by the author.

Each LED turns on or off by tracking the pedestrians' movement as a flock of seagulls. One or more pedestrians can start to play over the interactive installation.

OUTPUT / SECOND CARPET LAYER: LED grid

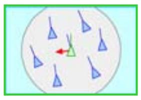
4.4 SOFTWARE DEVELOPMENT: DIGITAL CONTENT DISPLAYED

The Processing program used in this prototype is based on Alasdair Turner' Boids code, which is based on Craig Reynolds' rules described below. [Source: http://www.red3d.com/cwr/boids/applet/]

BOIDS PROGRAM

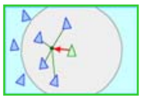
The Boids algorithm is a computer model of coordinated animal motion such as bird flocks and fish schools, created by Craig Reynolds who pioneered the concept of the flocking behaviour of birds as a completely decentralized activity. The basic flocking model uses simple rules to create complex behaviours, Boids algorithm consists of three simple steering behaviours, which describe how an individual boid manoeuvres based on the positions and velocities of its nearby flock members; the flocking behaviour of birds is a result of their individual behaviour and knowledge.

RULE 1 / Alignment: Boids try to fly towards the centre of a mass of neighbouring boids. The 'centre of mass' is simply the average position of all the boids.



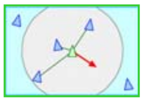
```
for (int i = 0; i < COUNT; i++) {
    Vec centre = new Vec();
    for (int j = 0; j < COUNT; j++) {
      if (i != j) {
        centre = add(centre, boids[j].m_pos);
      }
    }
centre = scale(centre, 1.0 / (COUNT-1.0));
Vec dir2centre = sub(centre, boids[i].m_pos);
    dir2centre.normalize();
```

RULE 2 / Cohesion: Boids try to match velocity with nearby boids. This is similar to Rule 1. However, instead of averaging the positions of the other boids, it averages the velocities.



```
Vec dir2centre = sub(centre, boids[i].m_pos);
    boids[i].m_speed = dir2centre.length() / 10.0;
    dir2centre.normalize();
```

RULE 3 / Separation: Boids try to keep a small distance away from other boids. The purpose of this rule is for boids to make sure that they don't collide with each other



```
for (int j = 0; j < COUNT; j++)  {
      if (i != j && dist(boids[i].m_pos,boids[j].m_pos) <50.0
)  {
        boids[i].m_dir = add(boids[i].m_dir,boids[j].m_dir);
        boids[i].m_dir.normalize();
      }
```

The Boid algorithm was selected for this prototype because it can bring a dynamic experience to the installation, where the pedestrian could be the “centre” of attraction of the boids/lights by positioning the user in the main role of the system. Also, emergent behaviour could be expected from part of the users and from part of the boids when more than one participant is interacting with the installation at the same time. Questions arise about which participant could be considered the centre of the boids system; how participants would react when boids tend to follow them; and how participants would react when boids tend to follow another user? Additional questions are addressed during the testing procedure.

Figure 7, Processing Boid's program, photos by the author.

4.5 PROCESSING PROGRAM INTERFACE

For testing the Processing program responding to Boids external inputs, the system was progressively changed to introduce external inputs in the system. This progression became increasing complex. A vector, called a "Vec destination", was created to define a specific destination for the flock of boids. The target location that the boids follow was changed according to external inputs:

1. Boids follow the location of the mouse on the screen.

```
Vec destination = new Vec(mouseX,mouseY);
    centre = add(boids[i].destination,centre);
    centre = scale (centre, 0.5);
```

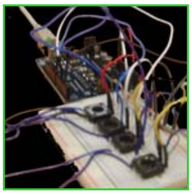
2. Boids follow the location of the mouse "click" on the screen: The "mousePressed" function changes the vector destination to the coordinates of the position of the mouse. Each time that the mouse "clicks" on the screen, the Boids achieve that new location. With this function, it is possible to simulate the input of many pedestrians in different locations.

```
void mousePressed ()
  {
    for (int i = 0; i < COUNT; i++)   {
      if (random (1) < 0.15) {
        boids[i].destination = new Vec(mouseX,mouseY);
        }
    }
 }
```

3. Boids follow the input values from Arduino Board. Once the Processing program receives the input values from the Arduino Board, the values, as integers, can be used in many forms. In this case, the values represent the coordinates of the location of the pedestrian over the carpet. In that regard, the input values received by the Processing program were used inside the Boid Class where the "buttonPressed" function was created. This function updates the destination vector (x_coord and y_ coord) each time that a button is pressed. The input values coming from Arduino can be assigned by a digital button or any kind of sensor, such as Pressure Pad sensors.

This function was tested by connecting four digital buttons to Arduino I/O Board.

```
void buttonPressed ()
  {
    for (int i = 0; i < COUNT; i++)   {
      if (random (1) < 0.15) {
         if(valueA == 50){
         boids[i].destination = new Vec(50,50);
         }
```



4. Boids follow the location assigned by a KeyPressed function. Another way to provide external inputs to the Processing program was through creating a KeyPressed function inside the Boid Class, which is recognized when a key, of any keyboard connected to the computer, is pressed assigning a new boid location.

```
void keyPressed () {
  println(keyCode);
    for (int i = 0; i < COUNT; i++)   {
    if (random (1) < 0.8) {
         if(keyCode == 49 ){                          //key 1
         boids[i].destination = new Vec(80,60);
         }
```

5. For the final prototype, the "buttonPressed" (case 3) function was used, but by connecting the 18 pressure pads directly to the Arduino board, instead of using digital buttons.

The Processing program was tested in public environments in two different situations, using two different interfaces:

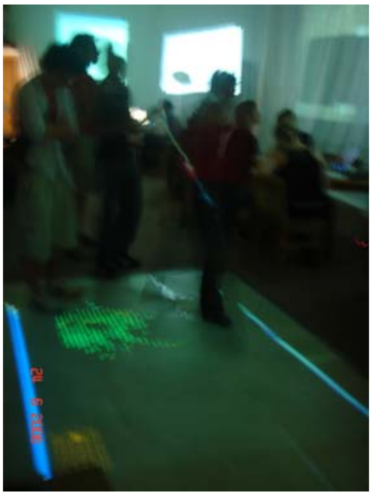


Figure 8, Open Days installation, photo by the author.

The first test was during the Open Days of the MSc AAC at University College London, on 24 and 25 June 2006. On this occasion, the program was tested using a data-show projector, which was located at the top (about 3 meters high) of a room, using a polished stainless steel (mirror). The image displayed was projected perpendicularly to the ground. On the ground, a Pressure Pads grid of 18 units was connected to an external keyboard, which sent the pedestrian position values to the Processing program. Over this carpet, a reflective and smooth surface of polythense colour pearl was displayed to protect the Pressure Pad carpet and reflect the image projected from the data-show.

The Processing interface was shown in this way:

On screen, the user can see a mesh fabric representing the 18 pressure pads. Each time that one is pressed, it changes its colour to orange so that the user can map his/her location over the carpet and easily understand how the installation system works.

The green dots represent the virtual LED-s turned ON.

The orange circles represent the boids

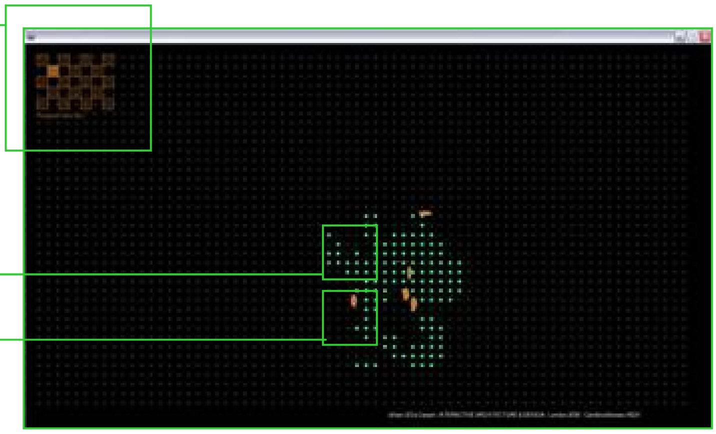


Figure 9, Processing program photo screen, by the author.

During the second test, in Bath city, the user cannot see the computer screen because the LED carpet was displayed. But on the screen, it was proportionally represented by the location of the modules of LED-s according to the real carpet:

The green squares represent the LED-s turned ON in the real LED carpet.

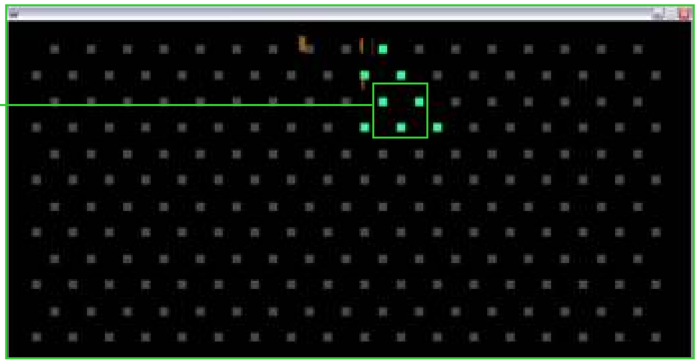
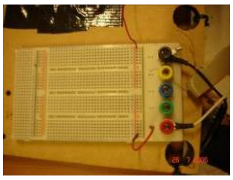


Figure 10, Processing program photo screen, by the author.

4.6 HARDWARE CONSTRUCTION, HOW LED-s URBAN CARPET IS TECHNICALLY ACHIEVED?

"Physical computing is about creating a conversation between the physical world and the virtual world of the computers." [O'Sullivan & Igoe, 2004, p. xix]

A) MATERIALS:


Solderless breadboard


Diagonal cutters, screwdriver, wire stripper, scissors


Tape


Soldering Iron and solder


Multimeter, battery charger & battery


Wire & ribbon cable


Pressure pads


LED-s (diodes)


Resistors, capacitors and transistors


Tool Box


34 pin LED Display Driver


Key board


16 pin-header IDC


MDF 3 mm


Mini-Vise

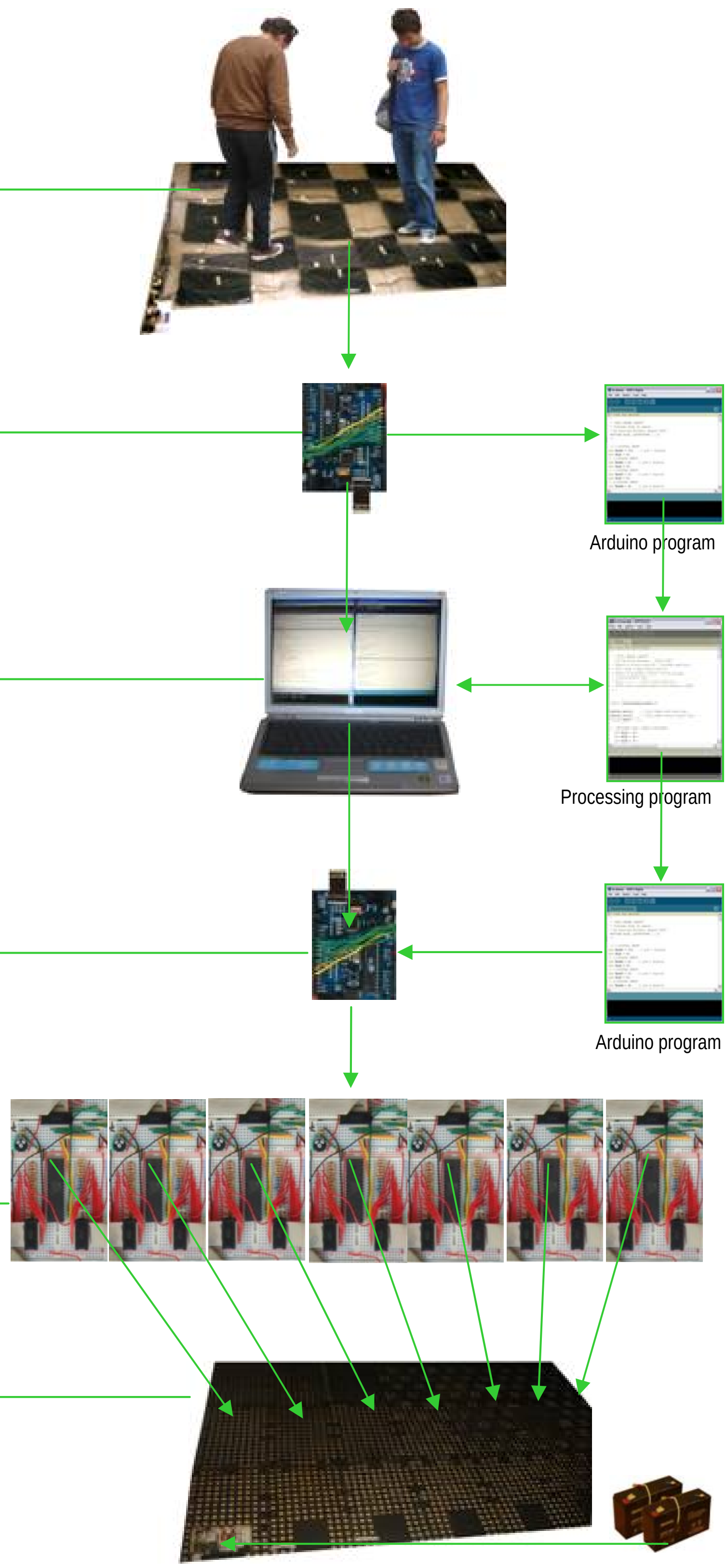
Figure 11, Materials used during the prototype building, photos by the author.


Figure 12, Arduino I/O board, source: www.arduino.cc

THE ARDUINO BOARD, this physical computing platform has:
14 Digital IO (pins 0 – 13) pins that can be inputs or outputs as set in software.
6 Analogue In (pins 0 – 5) pins that are dedicated analogue in pins. These take analogue values (i.e. current or voltage readings) and convert them into a number between 0 and 1023.
3 Analogue Out (pins 9, 10, 11) these are actually 3 of the digital pins that can be reassigned to do analogue output through the Arduino IDE.

B) THE BLUE-PRINT: in order to build something in a physical computer, the first step is to describe what should happen, the whole environment and requirements for the project.

Figure 13, LED-s Urban Carpet system diagram, draft by the author.



Pressure Pad Grid (runs with laptop battery)

First Arduino I/O board, (runs with laptop battery)
First Arduino program, listen for input values from 18 pressure pad sensors, and send the data to Processing.

Laptop (run with self battery)
Processing program, runs Boids program, controlling the whole system, receiving inputs from Arduino 1 and sending outputs to Arduino 2.

Second Arduino I/O board (run with laptop battery)
Second Arduino program, receives output values from Processing and control 7 LED Drivers, one for each row of the LED carpet.

7 LED Display Driver M5054 (34 pins), each one controls one row with 30 modules of LED in. Each module of LED has 4 units; the carpet has a total of 840 lights.

LED rubber Grid, (runs with external batteries) shaped with 21 mats door, 3 for each row.

2 batteries of 6Volts 12 amperes, supply power to the LED grid.

4.6.1 BUILDING THE PRESSURE PAD GRID

The Pressure Pad grid dimensions are 180 cm wide by 280 cm large by 5 mm high and composed of 18 digital pressure sensors posed over a plastic film. Thus, this electronic layer is flexible, foldable and light.

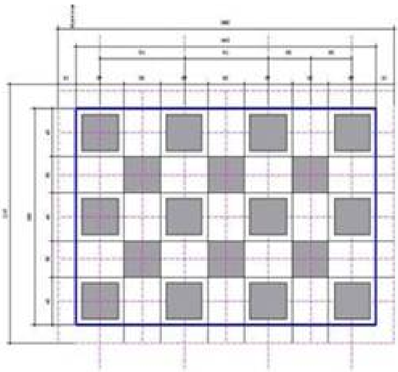


Figure 14, Pressure pads grid plan, by the author.

Figure 15, Pressure pads grid, photos by the author.

The first test of the Pressure Pad grid was using an old keyboard as a microcontroller. Each pressure pad was connected to a key such that pressing the sensor had the same effect as pressing a key.

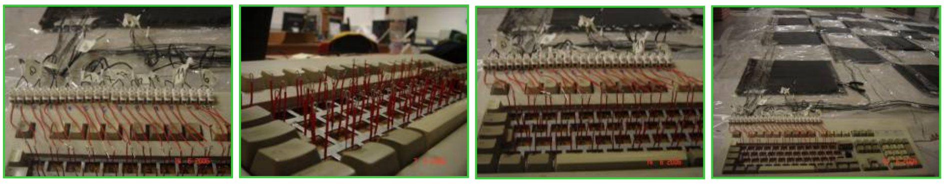


Figure 16, Pressure pads connected to a keyboard, photos by the author.

For the final prototype, the grid was connected to 13 digital inputs and 5 analogue inputs on the Arduino. The pressure pad is a component that connects two points in a circuit when pressed. The breadboard has a 10K resistor connected between the input pin and ground. The Arduino program receives inputs from the pressure pad grid, assigns a specific value name to each pressure pad input, and sends the values to the Processing program.

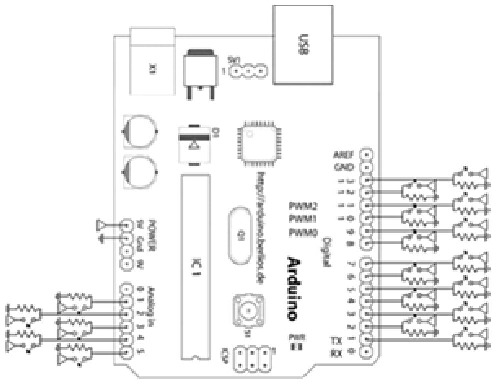


Figure 17, Arduino technical diagram controlling 18 pressure pads, by the author.

Figure 18, Arduino I/O board connected to 18 pressure pads, photos by the author.

4.6.2 BUILDING THE LED GRID

In order to build the LED grid and make it portable, the whole grid was divided into seven rows, where each row was controlled by one LED Display Driver M5054 and seven of them were controlled by one Arduino board, which was located in the last row and connected to the computer by a USB cable. The Arduino board received the output values from the Boids Processing program.

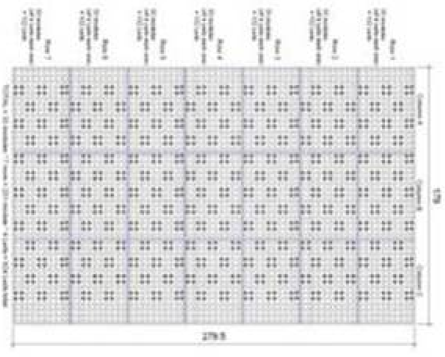


Figure 19, LED-s Grid plan, by the author.

The major challenge in the Processing program was how to send the output values from the state of 207 LED modules to the Arduino I/O Board. At the beginning, the idea was to send seven arrays of 30 values. Each one ("LEDArray [30]") was developed and tested. But, either for the Processing program or for Arduino it took a long time to send, receive and process that amount of data. Time was an important factor in the system, because the interaction and relation between the display and the user must be smooth and very sensitive, avoiding delays which could produce confusion or a boring experience.

A key issue in physical computing is how to store data, generally variables are used to store data in the memory of the program, update, change or replace them in a flexible way. The size of a variable and the way it's interpreted is called the "data type" and is determined by how large a number needs to be stored [O'Sullivan & Igoe, 2004]. The more commons type are:

- Bit = 1 bit, range values from 1 or 0,
- Byte = 8 bits, range values from 0 to 255
- Word=16 bits, range values from 0 to 65535

In that regard, the data from Processing to Arduino was sent in packages of Bytes, through the serial port. Serial data was passed byte by byte from one device to another. The Processing program sent 4 bytes for each row of the LED grid, as it shown in fig.20. On the other hand, the Arduino program received the package of bytes, and then assigned in order byte by byte for each LED driver. When the seven rows are completed; the buffer is cleaned; and the program restarted.

```
void writeSerial()
{
  for (int i = 0; i < 7; i++) {        // for 7 rows
     int output = 0;
     int shift = 0;
     for (int j = 0; j < 30; j++) {
        int x = i * 5 + j / 6;
        int y = j % 6;
        if (grid[x][y].on) {
           output |= 1 << shift;
        }
        shift++;
     }         // ready to send to the arduino board:
     byte b = 0;
     b = byte(output & 0xff);            // first byte
     port1.write(b);
     b = byte((output >> 8) & 0xff); // second byte
     port1.write(b);
     b = byte((output >> 16) & 0xff); // third byte
     port1.write(b);
     b = byte((output >> 24) & 0xff); // four byte
     port1.write(b);
  }
}
```

Figure 20, Processing piece of code for control the LED-s.

4.6.3 LED Display Driver M5054 (34 pins)

With the purpose of manipulating many inputs or outputs and managing a limited number of pins for the microcontroller (Arduino), it is possible to use external chips, which send (controlling multiple outputs) and receive (reading multiple inputs) the following:

- Shift registers, which control digital data.
- Multiplexers, which handle both digital and analog.
- Latches, which manipulate only multiple outputs from one input.

For this prototype, the LED Driver M5054 is used, which can multiply the outputs but only control LEDs. A LED driver, is a kind of shift register, which incorporates a displacement registration when it receives the data in series format and it transfers them in parallel. It is possible to chain chips according to the outline daisy chain[1], increasing the number of LED Drivers every time.

Starting to manage any type of chip, it is essential to refer to the data sheet[2] of the product for technical information about building the hardware before writing the software for control the chip. The key issues for handling this specific chip are:

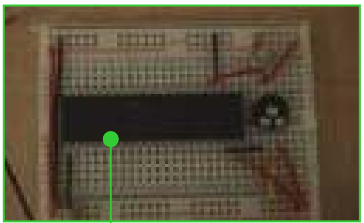


Figure 21, LED Driver Display, photo by the author.

LED DRIVER PINS OUTLINE:

CLOCK: (pin 21) sends pulses for timing the flow of data; 36 clocks are connected to one Arduino digital pin.
DATA IN: (pin 22) receives the data from the microcontroller and is connected to one Arduino digital pin.
DATA ENABLE: (pin 23) an optional pin connected to a resistor (1000k) and then to 5 Volts.
BRIGHTNESS CONTROL: (pin 19) controls the brightness of the LEDs with a transistor (100k).
5 VOLTS: (VDD – pin 20)
GROUND: (VSS – pin 1)
All the other pins are connected to the modules of LEDs through a resistor (200k), pins 2 to 18 and 24 to 40.

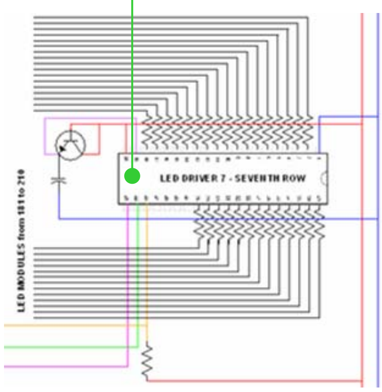


Figure 22, LED Driver technical diagram controlling 34 LEDs

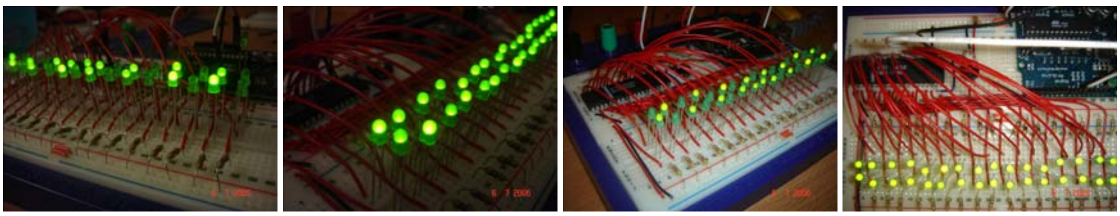


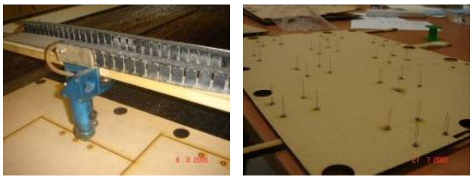
Figure 23, LED Driver controlling the array of LEDs.

[1] In electrical and electronic engineering, a daisy chain is a wiring scheme in which, for example, device A is wired to device B, device B is wired to device C, device C to device D, and so on. There is no loop back from the last device to the first. Source: www..wikipedia.org/

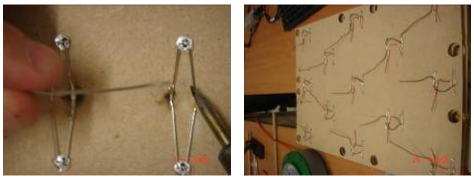
[2] Source: http://www.datasheetcatalog.com/datasheets_pdf/M/5/4/5/M5450.shtml

BUILDING THE CARPET

Once the LED Display Driver was handled and controlled in a proper way, the LED carpet was built module-by-module and row-by-row, as the next photographs illustrate:



Manufactured MDF layer where the 840 LED units were enclosed.



Soldered the LED modules to ground and five volts.

Connected the LED modules of each row to an LED Display Driver.

Figure 24, LED-s Carpet building process, photos by the author.

Subsequently, seven rows were manufactured, assembled and tested each time. Hardware and software problems were also debugged. The technical diagram of the seven LED Display Drivers is represented in Appendix I. Finally, both Arduino microcontrollers were put together, one for controlling the pressure pad grid and the other one for controlling the LED grid.

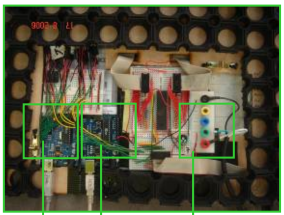


Figure 25, Two Ardunios controlling the LED-s Urban Carpet.

External battery supply connection

LED grid microcontroller

Pressure pad grid microcontroller

5. TESTING PROCESS

To address an understanding of the social and practical issues raised by the interactive installation in a public architectural space in Bath, the testing process included the following: 1) different locations were selected according the flow of public movement during the day, land use and the specific role of each location in relation to the city centre area; 2) a range of empirical observation methods and a questionnaire were implemented; 3) public interaction with the prototype was observed and annotated.

5.1 A STUDY OF THE SELECTED LOCATIONS FOR PROTOTYPE DISPLAY

Three locations within the centre of Bath were selected.

Riverside next to the west side of the Avon River and near the Pulteney Bridge

New Bond Place

Southgate Street

Figure 26, Bath city centre map.

Figure 27, Locations photographs, photos by the author.

The first area is located on the other side of the river, which is completely different from the other two locations because it is situated in a green zone. This side of the Avon River is mostly a park and a walking recreational area, where it is possible to find more locals than tourists. The flow of people is variable during the day. The second and third locations are situated in an urban central area, where tourists and locals pass constantly during the day. However, they present some variation in the kind of people who pass and the way the space is used. The three areas present a pedestrian condition such that the spatial configuration privileges the pedestrian movement rather than vehicles.

Also, when choosing the locations, size and character of the space were considered. Allowing passers-by to interact voluntarily with the display and installing it in a non-obstructive place were both considered.

5.2 OBSERVATION METHODS

The next methods of observation were applied to the study of each location:

- **Counting people:** This method establishes the flow of people at sampled location within the city over the course of a day. The procedure is to stand at a specific point within the study location and draw an imaginary line crossing the street space. People are then counted crossing this line for a set of period of 5 minutes. To determine the patterns of movement during the day in the location, three rounds of observations were undertaken: from 11:30 to 13:30, from 14:00 to 16:00 and from 16:30 to 18:30. [See to Appendix II]

- **Static Snapshots:** This method is especially relevant to record the use pattern of space for stationary and moving activities. The observer walks around the space for 5 minutes and takes snapshots of the activity precisely at the moment, which is then recorded on the plan of the area. This method was applied at the same three times indicated above.

5.3 LOCATION 1: RIVERSIDE PLACE

Figure 28, Photographs from River side place, by the authors.

This place is a green area near the centre that entices locals and tourists to enter. However, because this location does not offer good accessibility, people tend to enter only with a specific purpose such as eating lunch or boarding a tourist boat service. Also, local people use this space as a recreational area for sports and jogging. Land use shows mainly restaurants and pubs, opening during lunch time and at night.

The average number of people going to this location during the day is:

336 people per hour during lunch time

48 people per hour after lunch time

156 people per hour during the late afternoon

At this location, the test was carried out during the late afternoon when not many people were around the area. It was the intention to determine if displaying the installation could catch the attention of people around it.

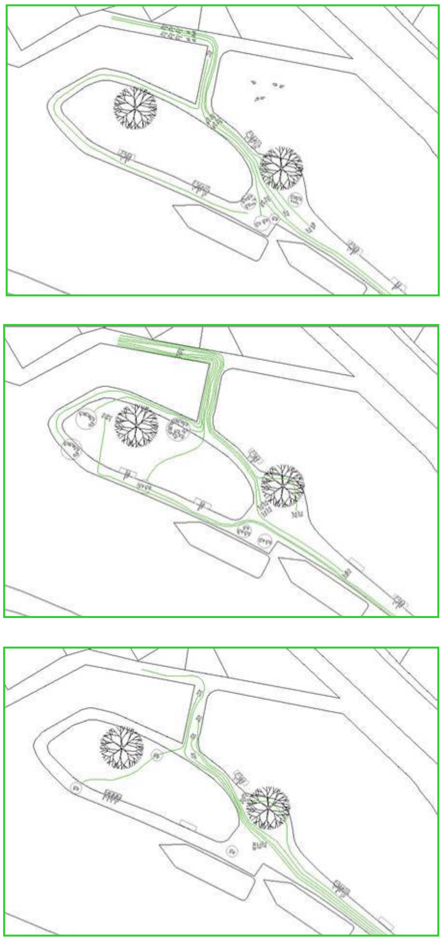


Figure 29, static snapshot diagrams from Riverside place at 13:00 , 15:00 & 17:00 hrs, by the author.

TESTING PROCESS

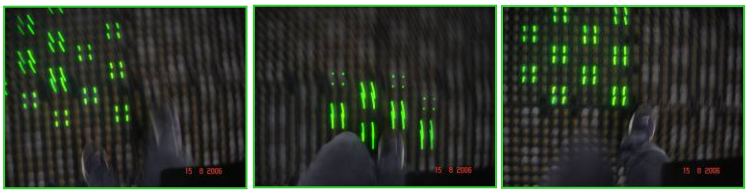
During the testing process in all three locations, some common social behaviours and reaction of people around the display were observed, which are listed below. Then, the specific emergent interactions for each test will be described in each location section.

COMMON ERMERGENT PATTERNS

While assembling the prototype, passers-by gathered around the area to see what was going on. Some asked for information about the prototype suggesting curiosity at this stage.

Once the installation was set up, people asked how it worked. After an explanation and a demonstration, some people started to interact with the prototype while others watched.

The time it took for people to understand how the system worked and how the LED Carpet followed the position of their bodies over the interactive surface varied.



When at least one person started to interact with the prototype, other people became curious. Some gathered around the display while others stopped or slowed down to see the installation.

After trying the installation, some people commented on the experience and explained the rules of interaction to friends nearby.

Figure 30, Photographs taken from the test sessions, by Ava Fatah gen. Schieck and the author.

TEST AT RIVERSIDE LOCATION

Date: 15 August 2006

Time: 17:00 to 18:00

Weather conditions: Cloudy, rain interrupted the test. Weather conditions were not good for tourist or recreational activities.

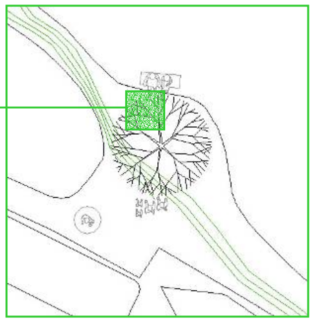


Figure 31, Location of the prototype at Riverside place, map by the author.

At this location, the test was carried out during the late afternoon when not many people were around the area. The intention was to determine if displaying the installation could catch people's attention and bring together towards the installation.

Despite expectations, assembling the prototype in this location did not attract people to it, even though people walked near it and glanced at it without stopping.
Not many people interacted with the installation, but those who did followed patterns similar to those described at the previous location.

Figure 32, photographs of the test session at Riverside place, by Ava Fatah gen. Schieck.

5.4 LOCATION 2: NEW BOND PLACE

Figure 33, photographs from New Bond place, by the author.

New Bond Place is a commercial area with mainly clothes stores and coffee shops. It is a junction surrounded by vehicular and pedestrian streets, like a virtual gate to the city centre because of the invisible boundary between residential and commercials areas. This location offers a spontaneous meeting point due to its architectural and physical characteristics; level area and benches that allow people to gather in groups and sit.

It is a crowded area during the day. People tend to move towards the city centre during the morning and in opposite direction during afternoon, when they return to home.

The average number of people moving around this location during the day is:

1656 people per hour during lunch time

2964 persons per hour after lunch time

2028 persons per hour during the late afternoon

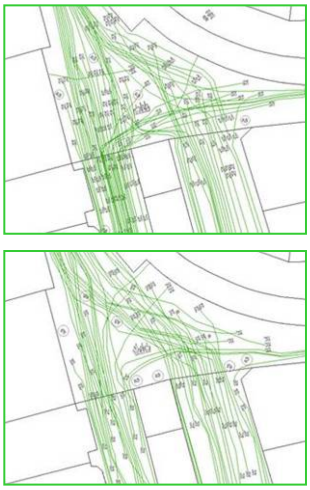


Figure 34, Static snapshot diagram from New Bondplace at 13:00 , 15:00 & 17:00 hrs, by the author.

At this location, two tests were carried out. The first test occurred after the lunch period when people were mainly window-shopping and strolling. A remarkable number of women passed by. Children and teenagers were also present. The second test was at night when businesses were closed. But, people at this time of the day go to or return from restaurants and pubs.

TEST AT NEW BOND PLACE (1)

Date: 16 August 2006

Time: 14:30 to 16:00

Weather conditions: Sunny

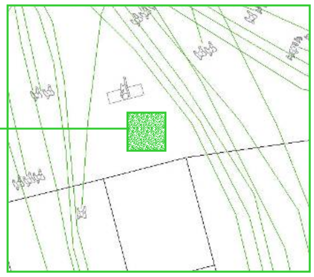


Figure 35, Location of the prototype at New Bond place, map by the author

Despite the difficulty in seeing the lights turn ON during a sunny day, teenagers started to interact with the installation without explanation. It was a group of about seven Spanish friends, who all walked over the carpet at the same time.

After a while, they realized that the LEDs were only reacting to a couple of them and not the whole group. Subsequently, they left the prototype so that two of them

could play at the same time.

They considered the installation as a type of game with each person proposing different rules to control the Boids and light reactions.

Children interacted with the prototype in a very spontaneous way. The physical interface caught their attention, especially the prototype's material. They then began to play with the rubber carpet as well.

Figure 36, photographs of the test session at New Bond place, by the author.

TEST AT NEW BOND PLACE (2)

Date: 16 August 2006

Time: 21:30 to 23:00

Weather conditions: Partly cloudy.

During this test, the behaviours and patterns of interactions were completely different at night than at midday. At night, there was not a constant flow of people.

Figure 37, photographs from the test session at New Bond place, by the author.

However, the people who interacted with the prototype spent more time with the installation and around it. It also was noticed that once a group of people felt comfortable with the display, they just stayed there talking and socializing together for a long time.

Mainly teenagers but also adults interacted with the display. A kind of "party atmosphere" enhanced user response to the stimulus of the installation. Yet, some unexpected reactions were observed such as a person who lied down on the carpet and then rolled his body across it. Another person played with a ball over the carpet. Still others brought their pets to play on the carpet.

5.5 LOCATION 3: SOUTHGATE STREET

Figure 38, photographs from Southgate street, by the author.

Southgate place is a commercial and pedestrian area, it can also be considered as a virtual gate for the city centre since it is the beginning and end of the main pedestrian and commercial avenue. Here, people tend to spare time and meet in this place. The area is surrounded by big stores with a constant movement of people throughout the day.

Even at night, young people meet near fast food stores. The large proportion of space allows many situations to happen simultaneously without interrupting others.

Due to the constant traffic, this location is the most crowded of the three. People walk near the perimeter of the façades and leave the centre area for resting and sitting on benches.

The average number of people moving around this location during the day is:

2448 people per hour during lunch time

2736 people per hour after lunch time

2208 people per hour during the late afternoon

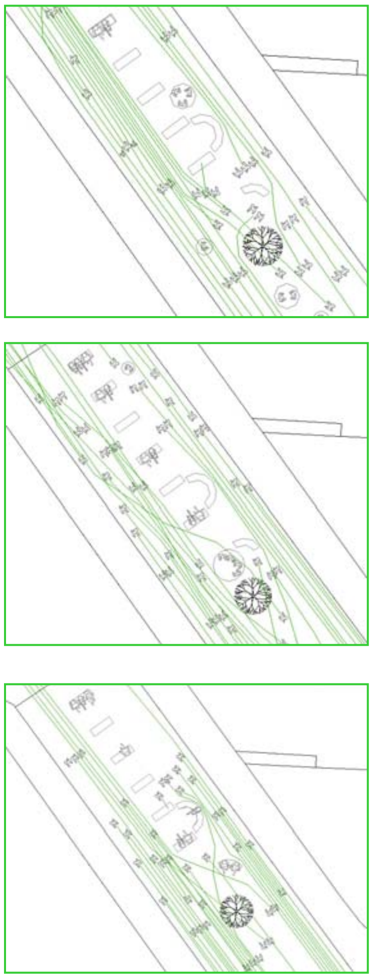


Figure 39,Static snapshot diagram from SouthGate place at 13:00 , 15:00 & 17:00 hrs, by the author.

At this location, the test was carried out late in the afternoon when businesses were closing, and people were returning home from work. The flow of people constantly decreased at this time of day.

TEST AT SOUTHGATE STREET

Location of installation

Date: 17 August 2006

Time: 18:15 to 19:45

Weather conditions: Cloudy with light rain.

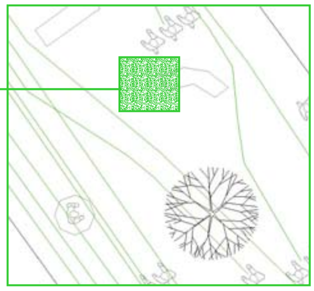


Figure 40, Location of the prototype at Southgate place, map by the author

During this test, the installation succeeded in gathering people around it and interacting with it. The location was not crowded at this time and people who played with the display spent a long time around it. However, most of the people just walked through the area without paying too much attention to what was happening near the prototype.

On hand, this public reaction might have happened because people are tired at this time of the day and tried to return home as quickly as possible, without stopping along the way. On the other hand, the physical condition of the location allowed people to walk around the perimeter of the area without noticing (interrupting) the display. For this location, the prototype did not seem big enough to attract people's attention.

Figure 41, photographs from test session at Southgate location, by the author.

5.6 QUESTIONNAIRE RESULTS

The research involved the distribution of a questionnaire to people who interacted with the prototype during the four sessions. A total of 27 forms were voluntarily filled out leading to some significant findings. The original questionnaire form and a quantitative evaluation of the returned forms can be found in Appendix III and IV. A summary of the evaluation and the most frequent answers and statements are given below.

Figure 42, photographs from test sessions, by Ava Fatah gen. Schieck.

The highest average of people who answered the questionnaire were between 21-30 years old (41%), most of them were students (44%) who were walking near the test location (41%). Ninety-six percent of the people interviewed liked the installation. However, most of them found it strange (52%) and interrupting the natural movement of passers-by in the area (37%).
While people were interacting with the display they mainly felt like playing (48%) and spending a fun time (48%). Also, they found the display a platform for social encounters (33%), where most of the time users were interacting with a friend (56%). Forty-eight percent of the people interviewed believed that this kind of technology is suitable for an urban context, like the city of Bath.

5.7 LIMITATIONS OF METHODOLOGY

During the testing process, the prototype and the methodology revealed some limitations and issues to improve across two main aspects: software and hardware.

In relation to the software aspects, the prototype:

- Does not allow many people interacting with it at the same time, the Boids and lights only respond to one input each time.
- The system interface was not so easy to understand as was speculated before testing the prototype. People's comments and the questionnaire revealed that 44% found the display more or less difficult to understand, which conflicts with one of the research objectives of this project.

In relation to the hardware aspects, the prototype:

- Presents a visibility limitation, because when the environment is too bright or sunny, it is not possible to see the LEDs patterns on the carpet easily.
- Presents a size limitation, because it is not big enough for certain open public environments where the display was too small in relation to the physical context. Thus, it was impossible to produce a real impact on the social surrounding, as some passers-by did not realized that the prototype was there.
- Presents a sensitive limitation, which does not allow following the accurate position of the user. Therefore, the sensors carpet must be denser.

5.8 RELEVANT FINDINGS

During the test sessions and observations of people's interaction with the installation in the urban and social environment of Bath, it was possible to ascertain these significant findings: 1) people flow around the LEDs Urban Carpet, which defined levels or types of interactions with the prototype and between people nearby, also due to this course of actions was possible to outline; and 2) an engagement process emergent from the relation between the user and the interactive display.

1. One of the main findings revealed was the direct relation between the way in which people gathered around the prototype and the kind of interaction that emerged between the user and the LED Urban Carpet, which are described next.

- Awareness. Different levels of awareness were noticed from people walking around the area, glancing at the interactive prototype, but then continuing their way, to people stopping around the prototype and asking about it, trying to understand how it works (peripheral awareness, to focal awareness to direct interaction). (fig. 43).

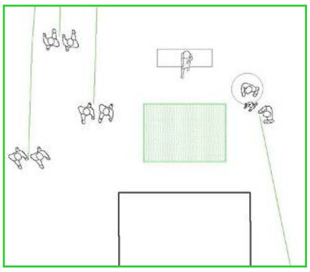


Figure 43, interaction diagram by the author

- Encourage and engagement. Once the user observes the installation, a period of time is required for the user to learn the rules of engagement and be aware of the social protocols. Normally during this period, the public gathers around the prototype and watches how others interacted with it before participating. (fig. 44).

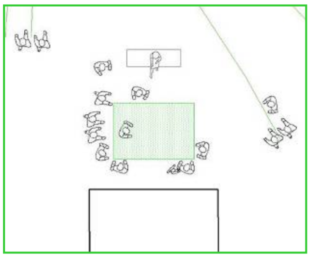


Figure 44, interaction diagram by the author.

- During this period, people tend to step over the perimeter of the carpet, once they familiarized with the display.
- During the familiarization period, the user concentrates on understanding how the system works and what they are supposed to do.
- When strangers interact at the same time with the prototype, they tend to stay on one side and not cross the area of the other user. (fig. 45).

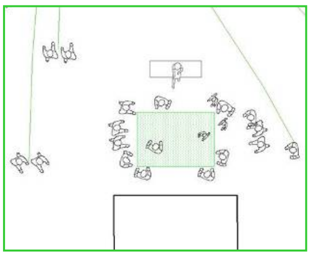


Figure 45, interaction diagram by the author.

- When friends are interacting with the prototype, they do not maintain certain distance between each other, and change position constantly across the interactive surface. (fig 46).
- Observers and active users gather at the perimeter of the display to give their impressions and comment on their experiences. It can be considered as a socializing period.

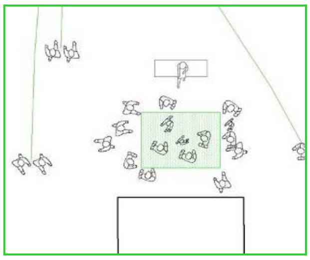


Figure 46, interaction diagram by the author.

2. In relation to the process described above, it is possible to argue that during the engagement process, public experimentation with the LEDs Urban Carpet was defined by clear states:

- First, there is an awareness of the experience, an awareness of the social environment and other activities; and an awareness of the installation, which in some cases was build up amid anticipation as people use relevant prior experience and expectations to a new experience (e.g., frequently the public characterized the prototype as a “dance carpet” before they interacted with it.)

- Next, engagement necessitated user need to learn the rules of the interaction and avoid social awkwardness and embarrassment around public display.

- Then, there is a period of immersion when user attention is focused on the interactive system. This state could vary from immersion to engrossment to total immersion.

- Finally, the test sessions have shown that the flow of people around a display is critical to understanding public-display social interaction. However the flow or movement of passers-by near the locations has a direct relation to the configuration of space. In other words, when the display was located in an area with a higher rate of pedestrian traffic (e.g.: Southgate street), it was more difficult to catch people’s attention than in locations where the speed flow tended to decrease due to the spatial characteristics of the physical environment (e.g: New Bond Place).

During this research, it was possible to understand, that one of the central problems in setting up new forms of technological surfaces in public space is people uncertainty regarding how to interact with the display. Overcoming this tension can be considered in terms of how best to design the transition between observers to participants. Discussing relevant findings and studying related literature should be taken into consideration for future work of this nature. The next section presents and discusses this challenge.

6. DISCUSSION

This paper suggests that changing the traditional scenarios where technologies have been developed and used (e.g. office and work environments), and exporting them to daily locations and well-known scenarios as public settings or urban environments, could open possibilities to generate new platforms for socializing, thus enhancing people's encounters and face-to-face interaction.

In relation to that problematic, this paper proposes the construction and testing of an interactive prototype situated in a public, urban environment. To answer the paper's questions, the LED Urban Carpet was developed and tested in three different locations in Bath. This investigation has revealed preliminary results, which suggest that the success or failure of a large interactive display depends on internal properties of the display and external factors of the social and physical surroundings.

This study has shown how the physical affordance of an interactive display engenders different kinds of social interactions. Some key findings have influenced the results obtained during the testing of the prototype: installing a large interactive display as a horizontal surface in a public space encourages people to walk over and congregate around it in a socially cohesive and conducive way. Also, people congregate around it or over it, in a non-hierarchical manner, where each user has the same possibilities for controlling the interaction.

More over, it was possible to observe that social proximity or person-to-person distance was necessary between the public interacting at the same time within the display. Distance was different between strangers compared to that between friends. In this regard, the LED Urban Carpet illustrates a weak point: Its size is not big enough to host the interaction between many people at the same time. During the test sessions, the most common pattern observed when strangers were interacting with the carpet was they waiting for their turn.

However, not only the physical properties of a display can have quite profound effects on the way it is used in a public setting, the affordance will also vary depending of the nature of the space where it is located (e.g., a park, street, bus stop, etc.). Each space has different attributes as do the people who are interacting with it [Gaver, 1991]. Accordingly, it is possible to argue that different kinds of surfaces will be needed to augment, support and enhance what people already do in that specific space.

Nevertheless, the affordance of the prototype represents only one of the main challenges. Enticing people to interact with the display was one of the big difficulties that the prototype faced. The LED Urban Carpet operates in the background or periphery of the user's attention and in a public setting where people are typically carrying out other activities. As such the users must be drawn to the display for it to become the focus of attention.

Engaging people to interact with a display of this nature will always be a difficult task. On the one hand some researchers argue the idea that people need to know in advance how the interactive display works and how to interact with it. Therefore, this information must be explained to the audience before exposing them to the interaction, "this helps the visitor to build up an idea of what to expect and make them feel more confident and in control" [Riet et al., 2005,p. 16].

On the other hand, William Gaver et al. argue that another resource for drawing people to interact with the design can be ambiguity, "Ambiguity can be frustrating, but also it can be intriguing, mysterious, and delightful" [2003, p.1]. By impelling people to interpret situations for themselves, it encourages them to start grappling conceptually with systems and their contexts, and thus establish a deeper and more personal relation with the display.

William Gaver et al. introduce ambiguity in the design with several advantages. It allows designers to engage users with issues without constraining how the interfaces respond. It allows the designer's point of view to be expressed while enabling users of different socio-cultural backgrounds to find their own interpretations. Finally, ambiguity can be evocative rather than didactic and mysterious rather than obvious, "Ambiguity is not a virtue for its own sake, nor should it be used as an excuse for poor design" [2003, p. 4].

However, people who expect clarity and consistency are more likely to perceive ambiguity as bad design of the prototype. The public will perceive the installation in dissimilar forms; this personal understanding and interaction with the prototype depends directly of the person's prior knowledge, similar personal experiences and cultural background. Hence, it is possible to deduce that a prototype which aims to augment a socializing experience, might include in its system cultural or familiar information so that the audience can understand in an explicit or implicit way, maybe without previous explanation.

Consequently, the ability of an interactive large urban display to enhance social interaction depends on the social atmosphere where it is located, the type of audience and cultural background, the affordance of the prototype, and the affordance of the environment where is located. Socializing experiences can be considered systemic, where each component of performance plays a crucial role for the functioning of the whole system.

The prototype developed in this project has the ability to attract and encourage the audience to take initial note of the system and then remain engaged during an initial encounter, even though it cannot have encourage people to establish a long period of interaction. That longer period could the audience time to become familiar with the display and the social surroundings and enhancing interaction between friends or strangers. The next section exposes the weak design issues of the prototype and discusses starting points for future works.

7. CONCLUSION

This research aims to present a theoretical and empirical study of the introduction of a new kind of technology in our physical environment. This paper exposes the concept, design, and implementation of a new ambient display. A prototype was suggested with the purpose of testing the research hypothesis. Then the LED Urban Carpet was constructed and tested in the city of Bath. Empirical findings were revealed during the testing process, which are exposed and discussed in relation to other research and projects of the same nature.

After the research experience, it is possible to conclude that large interactive public-displays have the potential to generate social interaction and awareness around them. However, situating them in different locations and social environments, diverse behaviours and reactions will emerge from the public, which designer could not necessarily predict. On the contrary, unlike controlled experiments conducted in a laboratory, public space trials do not facilitate prediction of who will attend, what other activities are happening or how much time people will spend interacting with the display. Testing in situ uncovers findings and failures that can refine the design.

Developing the LED Urban Carpet user trial and evaluation was a powerful way to understand the whole cycle of designing for a new medium. It is one step in a long array to augment the architectural envelop in order to create a social architectural space using means beyond traditional architectural elements, furniture, or standard information technology. The architectural space that we inhabit will be a new form of interface between humans and digital media, a kind of socializing architecture.

7.1 FUTURE WORKS

Based on the experience of this project described, suggestions for future work or improving the interface of the LED Urban Carpet are provided.

An interactive public-prototype has to include in its design audience awareness, audience attention, and ultimately audience interaction. In that regard, once the user understands how the LED Urban Carpet works and plays with it, the system is not capable to offer something new to the user to continue the interaction. One challenge is the addition of a modifying agent that learns from the interactions and automatically modifies or changes the original specification of the program. That agent could be human input or a component of the computer program that continues to evolve so that a predictable outcome does not occur.

In this kind of scenario, emerging behaviour could arise either from the installation or the participants. This evolution could depend on the history of interactions between humans and technological interfaces. Under these circumstances, it will be difficult for the user predict what will happen thus prolonging interaction with the interface and maybe expanding the socializing ambience around the display.

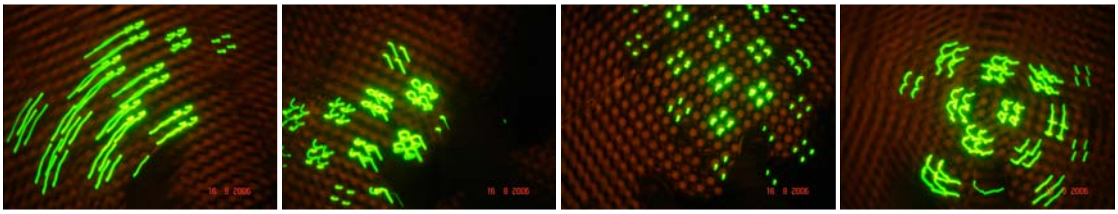


Figure 47, LED-s Urban Carpet, photos by the author.

APPENDIX

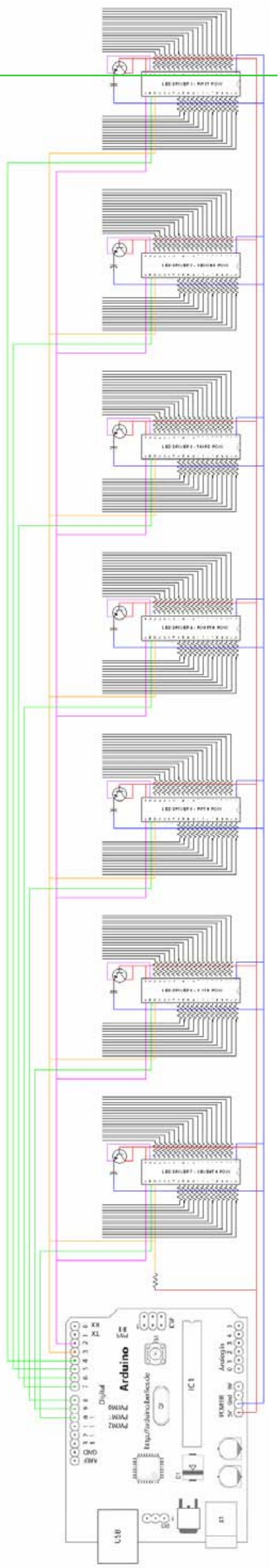
Appendix I: Arduino Technical Diagram

Appendix II: Gate Count details

Appendix III: Questionnaire form

Appendix IV: Questionnaire results

Appendix I: Arduino Technical Diagram



The system diagram of the LED grid is represented here, where only 9 digital input pins of the Arduino I/O board were used: one for CLOCK, one for DATA ENABLE, and seven pins for each DATA in the seven rows.

Appendix II: Gate Count Details

LEDs Urban Carpet
Data Observation - Bath City
The Gate Method - Based on Space Syntax methodology
Aug-06

LOCATIONS	River Side		Southgate		New Bond Place		
Date	15-Aug-06		16-Aug-06		15-Aug-06		11:30-13:30
Time	13:00 hrs	5 min	11:45 hrs	5 min	11:30 hrs	5 min	
Weather Conditions	Cloudy		light rain		Cloudy		
Mens:	11		64		43		
Womans:	13		81		65		
Older people:	0		23		17		
Childrens(3-13years)	4		36		13		
Others:	1 boat		0		0		
TOTAL:	**28**		**204**		**138**		
							
Date	15-Aug-06		16-Aug-06		15-Aug-06		14:00-16:00
Time	15:10 hrs	5 min	15:00 hrs	5 min	15:20 hrs	5 min	
Weather Conditions	Cloudy		Cloudy		Cloudy		
Mens:	2		70		54		
Womans:	2		120		139		
Older people:	0		13		25		
Childrens(3-13years)	0		25		29		
Others:	0		0		0		
TOTAL:	**4**		**228**		**247**		
							
Date	16-Aug-06		17-Aug-06		16-Aug-06		16:30 - 18:30
Time	17:00 hrs		17:30 hrs		16:40 hrs		
Weather Conditions	sunny		sunny		cloudy		
Mens:	5		63		68		
Womans:	5		89		80		
Older people:	0		9		4		
Childrens (3-13years):	3		23		17		
Others:	0		0		0		
TOTAL:	**13**		**184**		**169**		
							

Appendix III: Questionnaire form

LEDs URBAN CARPET INSTALLATION
Bath - August 2006
QUESTIONNAIRE
Location:
Date:
Time:

Weather Conditions:

RELATION BETWEEN THE INSTALLATION AND THE PHYSICAL ENVIRONMENT

1. Age Group
   - ☐ 1-10 years old
   - ☐ 11-20 years old
   - ☐ 21-30 years old
   - ☐ 31-40 years old
   - ☐ 41-50 years old
   - ☐ 51-60 years old
   - ☐ 61-70 years old
   - ☐ 71-80 years old
2. Profession
   - ☐ Pupil
   - ☐ Student
   - ☐ Others
   - ☐ House wife
   - ☐ Professional
3. Describe your activities in the area before interacting with the LED carpet.
   - ☐ sitting
   - ☐ walking
   - ☐ going towards ____________________________________
   - ☐ others
   - ☐ wandering
   - ☐ shopping/window shopping
   - describe _____________
4. Do you like the installation?
   - ☐ Yes
   - ☐ No
   - Describe:________________
5. The LEDs Urban Carpet is __________________with the physical conditions of environment
   - ☐ integrated
   - ☐ Strange
6. The LEDs Urban Carpet __________________ the natural movement of pedestrian.
   - ☐ interrupts
   - ☐ does not interrupt
   - ☐ is integrated with

RELATION BETWEEN THE INSTALLATION AND THE SOCIAL ENVIRONMENT

7. While I was using/interacting with the LEDs Urban Carpet I feel________________.
   (mark as many alternatives as you want)
   - ☐ Strange
   - ☐ Embraced
   - ☐ Disgusting
   - ☐ It is boring
   - ☐ Playing
   - ☐ Immersed
   - ☐ Funny
   - ☐ Social encounter
8. When I was interacting with the LEDs Urban Carpet I was ______________________.
   - ☐ interacting alone
   - ☐ interacting with a friend
   - ☐ interacting with one/other unknown people
   - ☐ There were more people but I was interacting alone

RELATION WITH THE INTERFACE AND THE TECHNOLOGY

9. Is the installation and how its works __________________ to understand and use.
   - ☐ Easy
   - ☐ More and less
   - ☐ Difficult
10. Is this kind of technology _______________ to appear in an urban and public context.
    - ☐ Suitable
    - ☐ More and less
    - ☐ Not suitable
11. Any comments to imrpve the experience ?

Thank you for your information and time.

Cityware project -University of Bath, University College London & other project partners.

Appendix IV: Questionnaire results

LEDs URBAN CARPET INSTALLATION
Bath - August 2006

QUESTIONNAIRE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTAL	%
Location:	River Side		New Bond				New Bond Street														Southgate Street								
Date:	15/ 08/ 06/		16/ 08/ 06/				16/ 08/ 06/														17/ 08/ 06/								
Time:	17:30 hrs		15:30 hrs				22:00 hrs														19:30 hrs								
Weather Conditions:	light rain		cloudy				cloudy/ nigth														cloudy - light rain								
RELATION BETWEEN THE INSTALLATION AND THE PHYSICAL ENVIRONMENT																													
1. Age Group																													
1-10 years old	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4%
11-20 years old	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	6	22%
21-30 years old	1	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	0	0	1	1	1	1	1	0	0	0	0	11	41%
31-40 years old	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	5	19%
41-50 years old	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4%
51-60 years old	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	7%
61-70 years old	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4%
71-80 years old	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
2. Profession																													
Pupil	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4%
Student	1	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	1	0	1	0	1	0	0	0	12	44%
Others	0	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	9	33%
House wife	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Professional carrier	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	5	19%
3. Describe your activities in the area before interacting with the LED carpet.																													
sitting	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	5	19%
walking	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	1	0	1	1	1	1	1	0	1	11	41%
going towards	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	5	19%
others	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	7%
wandering	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	4	15%
shopping/window shopping	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	5	19%
describe ______________																													
4. Do you like the installation?																													
Yes	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	26	96%
No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4%
5. The LEDs Urban Carpet is ___________________with the physical conditions of environment																													
integrated	0	0	1	0	0	0	1	0	1	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0	12	44%
Strange	1	1	0	1	1	1	0	1	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	14	52%
6. The LEDs Urban Carpet ___________________ the natural movement of pedestrian.																													
interrupts	0	0	1	0	1	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	10	37%
does not interrupt	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	0	1	0	0	1	1	9	33%
is integrated with	1	0	0	1	0	1	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	7	26%
RELATION BETWEEN THE INSTALLATION AND THE SOCIAL ENVIRONMENT																													
7. While I was using/interacting with the LEDs Urban Carpet I feel_________________. (mark as many alternatives as you want)																													
Strange	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	1	0	7	26%
Embraced	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3	11%
Disgusting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
It is boring	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Playing	1	1	1	0	0	0	1	1	1	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	1	0	1	13	48%
Immersed	0	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	19%
Funny	1	0	1	0	0	1	1	1	1	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	0	13	48%
Social encounter	0	0	1	0	0	0	1	0	1	0	1	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	0	9	33%
8. When I was interacting with the LEDs Urban Carpet I was _______________.																													
Interacting alone	1	1	0	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	11	41%
Interacting with a friend	1	0	1	0	0	1	1	1	0	0	0	1	1	1	1	1	0	1	1	1	0	0	1	1	0	0	0	15	56%
Interacting with one/other unknown people	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	15%
There were more people but I was interacting alone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
RELATION WITH THE INTERFACE AND THE TECHNOLOGY																													
9. Is the Installation and how its works ___________________ to understand and use.																													
Easy	1	1	0	0	0	1	0	0	1	0	1	0	1	1	0	0	1	0	1	1	1	1	1	0	1	0	1	15	56%
More and less	0	0	1	1	1	0	1	1	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0	1	0	0	1	12	44%
Difficult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4%
10. Is this kind of technology _______________ to appear in an urban and public context.																													
Suitable	0	0	1	0	1	0	1	0	1	0	1	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	13	48%
More and less	1	1	0	1	0	1	0	1	0	1	0	0	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0	11	41%
Not suitable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%

11. Any comments to imrpve the experience?

"put up a sign to explain what is it", "place within a modern surrounding", "brighter lights", "differents colours", "bigger"
"with some music...", "clear patterns", "a game", "poster explaining", "more sensitive", "in a rural environment", "robust design"

Thank you for your information and time.
Cityware project -University of Bath, University College London & other project partners.

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