LightStories: Designing and Evaluating Interactive and Participatory Urban Lighting

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ABSTRACT
This position paper presents an interactive and participatory urban lighting case study in a pedestrian-oriented street in the city centre of Oulu, Finland. The case study – *LightStories* (Valotarina) – explores methods to enable city dwellers to participate in the design of public urban lighting, as well as interaction and communication through urban lighting. It applies a web-based design tool, which offers city dwellers the opportunity to devise one-hour-long dynamic lighting designs displayed along a pedestrian-oriented street. In this paper, we will describe the design and development process of the lighting system and the participatory design tools used in the case, as well as the evaluation methods used to gain the feedback from the participants.

LightStories is part of the "Adaptive Urban Lighting – Algorithm Aided Lighting Design" (AUL) research project, which is carried out during 2011-2013 at the University of Oulu, Department of Architecture. The aim of the project is to research and develop algorithm aided design methods and tools for designing adaptive urban lighting. Parallel interests with Human-Computer Interaction (HCI) research, resulting from their turn towards research in real-world urban settings, have provided a basis for multidisciplinary research co-operation. Besides illustrating the LightStories case study, this paper briefly presents the research question and aims of the Adaptive Urban Lighting project.

Author Keywords
urban lighting, adaptive, participatory, interactive, algorithmic design, architecture, evaluation, public space

ACM Classification Keywords
J.5 [**Computer Applications**]: Arts and Humanities – *Architecture.*

1. INTRODUCTION

Lighting design for urban environments is gradually changing from static lighting towards dynamic and adaptive lighting. With the help of various sensors and transmitters, lighting can adapt to prevailing environmental conditions and react to different stimuli and signals, such as presence, movement, noise, trace data, SMS-messages and web-based data. An intelligently controlled lighting system can also analyse the received data in order to learn and adapt its operation to respond to the needs of city inhabitants. The benefits of adaptive urban lighting are associated with, e.g., energy savings, traffic safety and pedestrians' feeling of security, and with the experiential value of an artificially lit environment.

The urban inhabitants' *sense of control* in regards to adaptive urban lighting varies. Lighting adaptation can occur independently of the users of urban space, or it can react to their presence and actions. On the other hand, lighting can affect the movement of people in the city, thus manipulating city life. Lighting adaptations can even occur as real time interactions between user and lighting, and thus involve bidirectional communication. This form of adaptive lighting can be called interactive. Examples of interactive lighting have been presented in many art installations, such as Target Breezeway by Legoland [1], Visual Echo by Jason Bruges Studio [2] and Swarm Light by rAndom International [3]. Susanne Seitinger *et al* [4] have blurred the boundaries between urban display and lighting systems

in the project *Urban Pixels*. Users of urban space can interact with the network of small movable light elements, which they call light pixels, either by physically placing them spontaneously in urban space, by triggering sensors, or by messages from their mobile devices. Urban lighting design can thus be seen as interaction design: the design of adaptive lighting to enable interaction between the various users of urban spaces, and to enable interaction between the urban luminous environment and its inhabitants. On a very high level of sense-of-control, the users of urban space may even clearly understand how their actions and choices determine the outcome as lighting. In this way, inhabitants can participate in the lighting design of public urban spaces, as is being done in our case project, LightStories.

Visions and prototypes of intelligent lighting control systems, which are part of the ubiquitous intelligent infrastructure of the city, are currently being presented both on the level of a whole city [5] and on the level of smaller urban environments [6]. However, the basis for designing adaptive and interactive urban lighting as well as its effects, are still rather poorly understood and little studied. Moreover, there is a lack of design methods and tools addressing this design field.

The Adaptive Urban Lighting project aims to address these needs by applying algorithmic design principles in real-world demos in order to develop suitable methods and tools to design adaptive lighting for urban environments. Through these demos, solutions for adaptive and interactive lighting are tested, and evaluation methods are developed in co-operation with UBI projects.

Adaptive urban lighting can be seen as a part of the larger UbiComp paradigm, i.e. the practice of embedding information processing and network communication into everyday human environments to continuously provide services, information and communication. [7] However, the evaluation of the resulting urban places, which have a digital aspect as well as physical and social aspects, is challenging; the traditional methods of interaction research have been shown to fall short of the task of evaluating "in the wild". [8, 9] Moreover, the currently emerging interests within the UbiComp research field, such as the call for experiential computing [10], are raising further needs for novel evaluation methods in order to ensure the responsible, useful and enjoyable application of ambient intelligence in the form of interactive lighting.

In the case of LightStories the focus of interest is on the inhabitants' sense of control, the participation process, as well as the effects of the demo on the participants' relationship to the place in question: a pedestrian-oriented street in the city centre of Oulu.

2. PROJECT AIMS, POSITIONING AND COLLABORATION

The objective of the *Adaptive Urban Lighting* project, which is being carried out during 2011-2013 at the University of Oulu, Department of Architecture, is to research and develop methods to apply algorithms in lighting design for adaptive urban lighting. Lighting is approached as an experiential element of public urban spaces in northern conditions, specifically from the perspective of pedestrians. One aim, on the level of basic research, is to define the concept of 'adaptive urban lighting' from an experiential point of view as the basis for design. Moreover, the target is to research and experiment different ways of implementing intelligent and responsive urban lighting in practice. Through this, it is possible to gain knowledge about how adaptive lighting is experienced in urban contexts; for example, how adaptive lighting influences the inhabitants' movements and actions in urban spaces.

Research questions could be formulated in the following way: What kind of algorithm aided design methods and tools would ease the design process of adaptive urban lighting? In which parts of the design process can they be utilised? How is 'adaptive urban lighting' defined as an object of design? What kind of benefits does the adaptability of lighting bring to urban lighting, and what kind of negative effects could its implementation cause? How does the intelligently controlled and interactive lighting influence the users' experience of the urban environment?

Adaptive lighting is approached from the viewpoint of experience of the inhabitant of urban environments. The versatile environmental experience of the user has been selected for the basis of design. These experimental lighting designs demonstrate how adaptability can influence the experience of urban environments in a positive way, on different levels of experience. The algorithmic methods and tools are being developed with the help of *use scenarios* and the design process of *real world* -demos. In the real world demos, temporary lighting installations applying intelligent lighting control in various urban environments are being built. In these real life experiments, different thematical starting points for adaptation are applied. The demos act both as real life development cases and test fields for algorithm aided methods, and as cases to study the implementation of adaptive lighting systems and its effects and user experiences.

These case studies are being conducted in collaboration with the *UBI Metrics* project, carried out at the University of Oulu during 2011-2014. The project is part of the continuing Urban Interactions (UBI) research conducted by the MediaTeam laboratory within the Department of Electrical and Information Engineering at the University of Oulu.

The aim of the UBI Metrics project is to develop methods for the summative evaluation of situated computing systems, a need which has resulted directly from the need to evaluate UbiComp systems in real-world settings. This major turn of interest places researchers squarely within the messy reality of the lived environment. The UbiComp research community, then, is in a situation where its' previous methods are not sufficient to address the challenges that real-world evaluation brings. Despite some promising steps into this direction, real-world evaluation is still in its infancy in the field of HCI research. Consequently, only a truly multidisciplinary sensibility can produce in-depth understanding of any locale with in-built environmental computing systems. Our research team, then, consists of researchers from such diverse fields as architecture, cultural anthropology, economics and computer science. Existing in-situ methods are charted and evaluated from a multidisciplinary point of view, and emerging novel methods will be applied to the study of existing ubicomp systems in real world settings. These existing systems have been built within the past decade or so in some of the related research projects carried out by the MediaTeam researchers at the University of Oulu.

3. THE LIGHTSTORIES CASE STUDY

In the LightStories demo, lighting was approached as an experiential, interactive, social and communicative element of a public urban space. The main concept of LightStories is to introduce a part of public street lighting as a forum for personal narratives, messages and greetings. Through this playful idea of a street lighting as a social media, people are invited to participate in the lighting design of a public street. For one hour at a time, anyone can have the power to decide what kind of atmosphere the lighting is creating there through RGB-LED stripes situated on the sides of street light poles.

3.1 User participation

User participation in lighting design is enabled through an easy-to-use web interface, which was designed, built and piloted in the project. Each participant books a suitable time for their story and creates a lighting design by choosing different colours, effects and at which tempo they are displayed. Additionally, users write a story, a message or a greeting, which relates to their lighting design. These texts are visible on the LightStories website and on the public *UBI* touchscreens in the city centre. Real-time video of the street is also displayed to illustrate the current story for the website users. The LightStories project was designed and realized during the autumn and winter 2011-2012. The design tool was in use and the LightStories were presented during February (Feb 5-29) 2012 along a pedestrian oriented street in the city centre of Oulu.

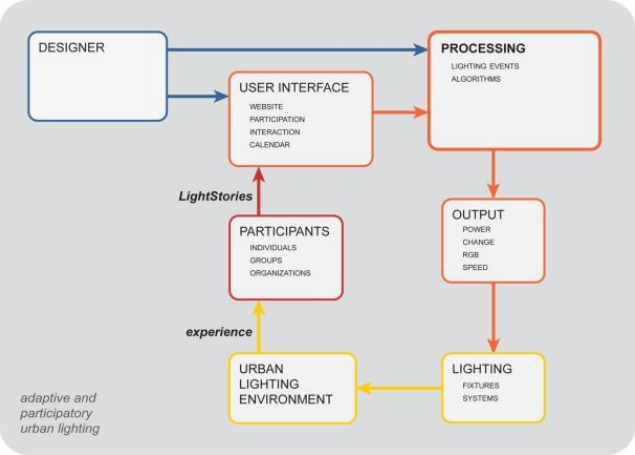

Figure 1. A diagram describing the process of adaptive and participatory urban lighting.

Figure 2. LightStories on a public *UBI* touchscreen in the city centre.

3.2 System and infrastructure

LightStories is a temporary lighting installation, but it uses the existing lighting infrastructure and ubiquitous technology built in the city (existing luminaires and lighting control device, cable and wireless network, public touchscreens). The control of the lighting fixtures is implemented using Pharos LPC (Lighting Playback Controller) lighting control unit [11] that we connected to the city's network. This allowed for the real time testing

and demoing of different lighting situations and effects. This part was crucial in the design of the controllable effects, as the simulation with the design software and how the lights actually appeared in real life differed greatly.

Normally, the Pharos LPC lighting control unit is used mainly for showing predetermined lighting animations and colour effects using time or control triggers. Pharos control unit's design software (Pharos Designer) is based on the sequential display of pre-determined effect and colour combinations, and as such does not readily offer the possibility to control these interactively. However, the design software offers the possibility to extend its capabilities through scripting with LUA scripting language. We used LUA scripting in combination with the Pharos Designer triggers to exceed the build-in limitations and functionality of the device by constructing our own parallel interface and functions. The effects were re-constructed with LUA scripts by using the existing Pharos effects as reference, and this allowed increased controllability and functionality to be built into the interactive effects. Participants' choices of colours, effects or other parameters, such as speed or direction, could then be inserted into the control program.

3.3 Key challenges and expected findings

As the evaluation of LightStories is still continuing, the final results will be published at a later date. In this paper, however, we can already discuss some challenges encountered during the design process, and also present some preliminary findings by reflecting on the design and evaluation process thus far.

Figure 3. Pakkahuoneenkatu street in Oulu with a user-generated lighting design.

LightStories was in operation in February 2012, during a period of 25 days. Within that time, 105 user-generated dynamic lighting designs were displayed in the pedestrian-oriented street. The associated stories varied from short greetings to longer narratives, describing, for example, a memorable situation in the writer's personal history, a current theme, or the writer's state of mind at the moment of creating the story. The last example could easily be likened to a status update in social media. The amount of stories created, and also the amount of visits on the website seem to be connected with the visibility of the project in local and national media. LightStories appeared twice in the local newspaper, and there were six radio broadcasts related to it (three on the local radio and three on the national level). Additionally, a report from the street was shown four times on television of which three times were on national television. These reports were also published on the website of the national broadcasting company YLE, accompanied by a video clip. Other channels of information were also used to promote LightStories: These involved mailing lists, Facebook, and posters and flyers distributed in the city centre. We found that the amount of visitors dropped whenever there was a longer break in media visibility. It can be said, then, that in order to invite participants, indeed, to make participatory design feasible at all, media visibility and advertising are necessary. On the other hand, our project team was surprised at how much public interest the project raised in the media on a national level, as well as locally.

Another challenge for creating interaction through participation is to make the process *fun* enough, and certainly not overly tedious, in order to attract the visitor landing on the first page to continue until the end of the process. The viewpoint of attractiveness was considered also during the design process of the tool. One central problem was how to strike a balance between the number of design choices that were offered to users and how uncomplicated and simple the user experience should be. Making the tool as easy-to-use as possible has the risk of limiting the users' freedom of choice, thus discouraging also their design aspirations. A design tool which is too simple and restricting may well be boring and frustrating if the users' expectations and design tool possibilities do not meet. How to maintain the users' sense of control, and how to make the process appealing and interesting enough? After all, this design tool is not meant for professionals but for everybody, including schoolchildren, and it should be attractive and encourage people to participate. Pedagogical aspects, amount of user instructions on the website, and the feedback process of the tool were also essential viewpoints.

Figure 4. The LightStories website and lighting design tool.

Our online participatory design tool was built around the concept of a *timeline*, which is used in many control device manufacturers' design programs. Each user's lighting scheme consisted of different kinds of partially pre-determined light events, both static and dynamic, which the users modified to their own preferences. Additionally, LightStories also combined a narrative, written by the user, to each lighting scheme. The utilisation of the narrative element was intended to help participants without previous design experience start designing dynamic lighting.

The main methods of evaluating LightStories are the semi-structured interview and a brief survey for all users of the LighStories website (www.valotarina.fi/en). The user-written narratives will also provide data for later analysis.

Based on preliminary findings, which are currently emerging from the interviews and the survey, we expect to find a wealth of information relating to the interviewees attitudes towards adaptive urban lighting in general, the LightStories demo and the participation process, and its effects on the interviewees' sense of control and their relationship to the place in question. Moreover, we are receiving valuable feedback from their experience of using the online design tool, and their ideas and wishes for further applications of adaptive lighting in regards to their daily environment.

4. RESULTS AND CONCLUSIONS

In the LightStories case study, lighting was approached as an experiential, interactive, social and communicative element of a public urban space. The built demo involved a complex real-world design situation, through which several aspects of adaptive urban lighting were studied.

This comprehensive approach to the case study, explored through its design, implementation and evaluation, has offered a wealth of new information, the complete results of which will be published at a later date. However, some of the knowledge and insights gained thus far have been elaborated on in this position paper. These preliminary findings include insights on the process of design and the evaluation of the interviewees' attitudes and ideas concerning participatory adaptive urban lighting.

5. ACKNOWLEDGMENTS

We would like to extend our thanks to the City of Oulu for their kind permission to use the street lights for the purposes of this research, and the city energy company, Oulun Energia, for their co-operation and assistance with the existing lighting infrastructure. Our sincerest thanks to our web developer, Jarmo Vähä, and to the leader of Adaptive Urban Lighting and UBI Urban Metrics projects, Dr. Aulikki Herneoja. We would like to thank the Academy of Finland for funding both the Adaptive Urban Lighting and UBI Metrics projects.

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