Results of the 'User Interaction Techniques for Future Lighting Systems' workshop at INTERACT 2011

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Abstract. Technological advances in lighting lead towards the development of intelligent LED systems and require reconsidering the way we interact with lighting systems. In this paper, we report on the workshop 'User Interaction Techniques for Future Lighting System' that was held in conjunction with INTERACT 2011 in Lisbon, Portugal. It was organized to initiate a dialogue between HCI researchers in the lighting domain and establish a research community around this emerging topic, as few researchers systematically study this matter. The goal of the workshop was to formulate the key research challenges for user interaction with future lighting systems. This paper summarizes the workshop paper contributions and the results of a creative session held during the workshop. Moreover, we present an initial list of research challenges for this emerging field.

Keywords: User Interaction, Lighting, LED, Smart lighting, Ambient Intelligence

1 Introduction

The Light Emitting Diode (LED) is causing a profound change within the lighting industry. This is mostly due to the LED's key properties of being physically small, highly efficient, digitally controlled and soon, very cheap to manufacture [1].

In the past, the single light bulb was controlled using a single switch: on and off. In contrast, LED-based lighting systems can easily consist of hundreds of separate light sources, with each source having many individually controllable parameters including color, intensity, and saturation. It is unreasonable and unrealistic to assume that end users of such lighting systems will be able or willing to manage this complexity. One way to address it is to enrich lighting systems with sensor networks that will enable automatic lighting control that is based on contextual information [2]. However, as

functionality and complexity of light systems grow, the mapping between the sensor data and the desired light outcome will become fuzzy; the users therefore, may wish to control this mapping rather than the light directly, or they may require an explicit user interaction for simply fine tuning the light outcome generated by an autonomous system. Explicit interaction may be more desirable for end-users, since they want to feel in control while interacting with intelligent lighting systems. The light switch therefore in many situations will need to be replaced by novel forms of interactions that offer richer interaction possibilities such as tangible, multi-touch, or gesture-based user interfaces.

From literature, there are only a few examples of how such emerging user interfaces (UIs) can be applied to lighting. Lucero et al. present a light control for controlling atmospheric lighting in a bathroom that uses the weather as a metaphor for describing light effects. They use a device with a small touch screen that can replace a conventional light switch [3]. Ross introduced a tangible object to set atmosphere in a living room [4]. In another publication, Mason and Engelen have described a tangible user interface for controlling light in a hotel room [5]. As proliferation of LED light continues, it becomes more important to go beyond scattered design efforts and systematically study user interaction with emerging lighting systems.

This change in how we illuminate our environments needs to be understood from a number of perspectives. How will people appreciate the greater functionality offered by the LED? How will they use LED systems and interact with it? What aspects do they want to control?

For the reasons mentioned above, we decided to organize a full-day workshop on user interaction techniques for future lighting systems at the 13th IFIP TC13 Conference on Human-Computer Interaction [6]. In the remainder of this paper, we elaborate on the goals and the results of this workshop.

2 Workshop setup

The focus of this workshop was on formulating key research challenges for user interaction with future lighting systems, creating initial design guidelines, and proposing novel interaction techniques for these systems. The main goals of the workshop were:

1. *Take a first step toward expanding the scope of interactive technologies to include new forms of decorative, ambient, and task lighting*;
2. *Identify key challenges of UI for controlling new forms of lighting systems*;
3. *Establish a link with existing interaction paradigms that can be (re-)used for control of future lighting systems*.

In the morning session of the workshop, a video presentation on the topic by Prof. Emile Aarts ('Liberation of Light') was shown to and discussed among the workshop participants [7]. Thereafter, all accepted papers were presented by the participating authors. At the end of the morning session, we extracted the main research challenges from the presented material. In the afternoon, the topic was explored in a playful way

through a creative session involving brainstorming, mood board creation, and ideation with physical props.

3 Results of the workshop

In this section, we summarize the results of the three main activities of the workshop: the paper contributions, the discussion on the key research challenges for this new domain, and the creative session.

3.1 Paper contributions

Six papers were accepted and included in the INTERACT 2011 workshop proceedings [7]. Segall and others introduce the concept of Semantic Light and the Semantic Light research program at KTH in Stockholm, which deals with creating smarter lighting solutions that have awareness of humans, context, and semantic information [8]. Offermans and colleagues propose the concept of lighting platforms and apps [9]. Other than developing interesting lighting concepts and a service infrastructure, the authors aim to investigate new paradigms for interaction with these new environments. The third paper reports on an exploratory study into the perception of dynamic lighting and how this type of research contributes to an understanding of the potential of LED systems and new UI concepts [10]. The authors of the fourth paper explore the use of LED-based lighting in the office environment [11]. They developed and evaluated two user interfaces: one with individual control of light parameters and the other preset-based. Alessandrini and others present the MeShirt concept; an interactive t-shirt that allows text and simple graphics to be visualized, using the fabric and LED based displays [12]. It allows users in real-time to express their opinions and comments on the world around them, in a citizen journalism spirit. The final paper addresses the problem of energy efficiency in underground parking garages and the authors propose new illumination control strategies that leverage the unique features of LEDs and take into account the specificity of parking garages and their usage patterns [13].

A wide variety of topics and domains have been addressed in the workshop papers, all with domain-specific and general challenges when it comes to the design of the user-system interaction. Several key challenges were extracted from the paper presentations, as well as from the video presentation ‘Liberation of Light’, and served as a starting point for the formulation and discussion of the main research themes in user interaction techniques for future lighting systems.

3.2 Formulating research themes

During the workshop, a list of research topics related to LED illumination was structured and discussed. The main research themes that emerged from the presentations and follow-up discussions were:

- Human perception of light

    - Perception of dynamic lighting
    - Visual comfort of LEDs
    - Understanding and mental models of light and colours
    - Intercultural differences
- Impact of light on people
    - Psychological effects of light
    - Physiological effects of light
- Light as medium
    - Light as information carrier
    - Ambient displays
- Lighting UI solutions
    - Natural interaction solutions
    - Multiple users support
    - Control for large area illumination
    - Allocation of control (system vs. user)
- Illumination of environments
    - Balance between functional lighting and fun / decorative lighting
    - Integration of natural light and artificial light
    - Balance between energy saving and optimal user comfort
- Lighting applications
    - Lighting services and platforms
    - Quantifying the added value of UI solutions in lighting systems

Please note that this is just an initial list of interesting research topics that we hope will grow and become more concrete in the future. While discussing the above challenges, the multi-disciplinary nature of this emerging research field became apparent. It was suggested by several participants to re-use knowledge, methods, and models. from other disciplines including computer science, human factors, human-computer interaction, environmental psychology, physics, human perception, biology, and design.

3.3 Creative session

In the afternoon part of the workshop, we held a creative session with the goal to generate innovative user interaction ideas for future lighting systems. First, the participants brainstormed about the potential *who* ('Who is controlling the lighting system?'), *what* ('What elements of the lighting system are being controlled?'), *where* ('In which context is the lighting system used'), and *why* ('Why is the user controlling the light') of a future lighting system. Subsequently, three arbitrary combinations of *who, what, where,* and *when* were made. These combinations were the starting point for a group to create a mood board reflecting the envisioned future lighting system. Figure 1 shows an example of a mood board that was created during the workshop.

When assessing the constructed mood boards it became patently clear that there was a great variety of lighting ambiences that were possible and most were of a complex nature such as dappled sunlight through trees. These would be complex to design and a number of control issues were envisioned based on the specific context

or user, which supports our plea to rethink how people interact with future lighting systems.

At the end of the workshop, one mood board was selected and each participant had one minute to come up with an innovative user interaction solution, while making use of a physical prop that he or she got from the moderator. Video recordings were made while participants acted out the new interaction solutions.

Fig. 1 Impression of the creative session (left) and an example of a mood board (right). More pictures can be found on the workshop website [7]

As the mood board session, the physical prop session demonstrated how many different methods there could be to control light in these different contexts. Many ideas from the participants seemed to be novel, which may also be an indication that there is opportunity in expanding the scope of interaction technology to include lighting as a 'material' or service to be controlled.

4 Discussion and future work

The aim for this workshop was to explore three aspects of lighting and its control. The first aspect was to expand the scope of interaction technology to include lighting control. From the discussion and output of this workshop it appears that this is indeed possible and necessary should we want to ensure a future with light that we can control and enjoy. The second aim was to determine the challenges for future UI. With the aid of mood board generation, it became clear that light is complex and varied enough to require further investigation into how it should be controlled. A long list of potential research topics was also generated that provides a starting point from which to explore this topic area. The third aspect was to identify interaction paradigms that could be utilized for the purpose of lighting control and at this early stage, the prop session resulted in inspiring ideas for tangible interaction.

It became clear that putting the new forms lighting at the service of humans is a highly relevant research topic that will have to be pursued in multidisciplinary fashion

drawing contributions from experts in areas such as illumination, computer science, communication sciences, among other.

Using the research topics identified during the workshop the follow up workshop that is focusing on combining intelligent control systems with explicit user control is being organized.

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