Designing Interactive Lighting

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ABSTRACT
LED-based lighting systems have introduced radically new possibilities in the area of artificial lighting. Being physically small the LED can be positioned or embedded into luminaires, materials and even the very fabric of a building or environment. Hundreds of LEDs can be used in a single luminaire or space, of which each could have different light output properties. The light switch therefore in many situations will need to be enhanced or fully replaced by intelligent controls and smart environments that are sensitive to the context and responsive to the people in the environment. The focus of this workshop is to explore new ways of interacting with light where lighting is no longer simply an on or off system, but a flexible system capable of creating a large range of functional, decorative and ambient light effects.

Author Keywords
Lighting; User Interaction; LED; Implicit interaction; Smart lighting

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors

INTRODUCTION
The Light Emitting Diode (LED) has caused a profound change within the lighting industry. This is due in part to the LED's key properties of being physically small, highly efficient, digitally controlled and soon, very cheap to manufacture. Being physically small the LED can be positioned or embedded into luminaires, materials and even the very fabric of a building or environment [1].

In the past, the single light bulb was controlled using a single switch; on and off. LED-based lighting systems can easily consist of hundreds of separate light sources, with each source having many individually controllable parameters including colour, intensity, and saturation. These new functionality and flexibility come at a price of increased complexity. It is unreasonable and unrealistic to assume that end users of such lighting systems will be able or willing to manage this complexity. The ratio of the effort required to obtain the reward of beautiful and advanced lighting needs to be carefully managed. One direction that is being explored is to enrich lighting systems with sensor networks that will enable intelligent and autonomous lighting control that is based on contextual or implicit user information [9].

In many situations, such as setting up atmospheric lighting, an explicit user interaction may still be required. Moreover, as functionality and complexity of light systems grow, the mapping between the sensor data and the desired light outcome will become fuzzy and may require an explicit user interaction for fine tuning the outcome or for adjusting the mapping between the sensors' inputs and the light output. Thirdly, explicit interaction can be desired to allow users 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 [2, 3].

In previous workshops on this subject, a number of topics were identified as being the core of this research into 'Interactive Ambient Lighting': semantics of light; light applications and technology; multi-user; and interaction paradigms. In this workshop we want to explore two of these topics: multi-user aspects and interaction paradigms.

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GOALS OF THE WORKSHOP

In the previous workshops [7, 8] the domain of interactive lighting was outlined and our initial vision was formulated. The focus of this workshop is on multi-user aspects of future lighting systems and interaction paradigms, as well on methodologies to evaluate these novel interactive lighting systems.

1. *Identify key UI challenges for new forms of interactive lighting systems in a multi-user context*.
   Since the flexibility of future lighting systems will increase, this enables a more personalized approach to lighting and its control. This might create a diverse range of desirable light effects in multi-user contexts (such as offices). The first challenge is to address this personal diversity in lighting needs and controls. Moreover, as we have mentioned in the introduction, the complexity and the flexibility of new light systems will require at least a partial automation of light control to avoid overly complex UI solutions. The challenge here is to identify the optimum balance between internal system control and multi-user control, which is important for the appreciation and acceptance of the lighting systems [4]. Another challenge is the mapping between *system parameters* such as intensity and color, and *parameters of use* such as visibility and atmosphere. An example of this is providing users with the option to "set color temperature to 2500K" versus "create a warm atmosphere". Additional challenges for interaction with lighting systems also include, the communication of the system's possibilities, the actions required to access these possibilities, and the feed forward and feedback mechanisms [6]. This is especially important in situations where light sources are embedded into the environment and thus are hidden.
2. *Establish a link with existing interaction paradigms that can be (re-)used for control of future lighting systems.*
   Knowledge developed in various interaction paradigms could inform the interaction design of novel lighting systems. Some interesting directions to explore are the use of interaction techniques developed for multi-user contexts, such as tabletop, gesture-based interaction, ambient displays, and multi-display environments.
3. *Examine adequate methodology evaluating novel interactions with light.*
   Since this area of interest is new and evolving, a formalized design and evaluation process is still being explored. The majority of research undertaken in this area applied a mixture of qualitative evaluation methods (e.g. interviews, diaries, questionnaires) to assess the lighting systems. A recent discussion in the community proposed extending these procedures [5], by adding elements that focused on the users' *emotional states* while interacting with these systems.

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