The Role of Ambient Intelligence in Future Lighting Systems – summary of the workshop

Bernt Meerbeek[1], Dzmitry Aliakseyeu[1], Jon Mason[1], Harm van Essen[2], Serge Offermans[2]

[1] Philips Research Europe, 5656 Eindhoven, The Netherlands
[2] TU Eindhoven, Industrial Design department, Eindhoven, The Netherlands
{bernt.meerbeek, dzmitry.aliakseyeu, jon.mason}@philips.com
{h.a.v.essen, s.a.m.offermans}@tue.nl

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 could also 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. Future lighting systems will become a part of the Ambient Intelligence (AmI). In this workshop, we explored how the vision and principles of the AmI paradigm can be applied to future lighting systems that are capable of creating a large range of functional, decorative, and ambient light effects. This paper summarizes the workshop paper contributions and the outcome of our discussion on the key design and research challenges for the field of Interactive Ambient Lighting systems.

Keywords: Ambient Intelligence; Lighting; User Interaction; LED;

1 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 other words, our future lighting systems will be *ambient*.

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. The price to pay for all this functionality and flexibility is 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 LED lighting needs to be carefully managed. One direction that is being explored is to enrich lighting systems with sensor networks that will enable automatic lighting control based on contextual information [2]. However, other directions will need to be defined and explored also. But in sum, future lighting systems will need to be *intelligent*.

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 sensors 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. As the proliferation of LEDs continue, it becomes more important to go beyond scattered design efforts [2, 3] and systematically study user interaction with emerging lighting systems.

For the reasons mentioned above, we decided to organize a full-day workshop on the 'The Role of Ambient Intelligence in Future Lighting Systems' at the International Joint Conference on Ambient Intelligence 2011 in Amsterdam. In the remainder of this paper, we elaborate on the goal and the results of this workshop.

2   Goal and setup of the workshop

The goal of this workshop was to explore how the vision and principles of the Ambient Intelligence [4] (i.e. embedded, context-aware, personalized, adaptive, and anticipatory) can be applied to the interaction with future lighting systems. This exploration should help to identify and formulate the key research and design challenges for Interactive Ambient 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 [5]. Thereafter, all accepted papers were shortly presented by the authors and discussed with the audience. During the presentations, participants wrote keywords on cards to capture topics that were considered relevant for the afternoon discussion on the domain of Interactive Ambient Lighting systems. In the afternoon, the cards with keywords were put on a large table, discussed and clustered by the participants (see Figure 1). In this affinity diagramming exercise, also the relations between clusters were identified. In a second round, each cluster was discussed in more detail. Are these topics in the right cluster? Are there any topics missing? Do we consider this cluster of topics in the core of the emerging research field?

Figure 1 Affinity diagramming: discussing and clustering cards with keywords on a big table

3. Workshop results

Seven papers were accepted and are included in the Ambient Intelligence 2011 workshop proceedings. The first paper describes the main results of a similar workshop that was held in conjunction with INTERACT 2011 in Lisbon, Portugal [6]. The paper of Heuten and Boll addresses the topic of light as an information carrier. They investigate the use of light to remind older people of calendar events. Kuijsters and colleagues also focus on lighting applications for the elderly. More specifically, they present their plans to investigate the effect of coloured lighting on the mood of elderly. Two other papers focus on lighting in the public domain. Karamouzi et al. describe their idea to use dynamic lighting as a design tool to achieve amenity and sustainability in public open spaces. Wiethoff and Gehring present two examples of novel interaction methods with light, through explicit and implicit control mechanisms. Kahn and colleagues propose a new evaluation method of user interaction with lighting that uses mixed reality environments. Finally, Offermans, Van Essen en Eggen describe their vision on using an apps and platform approach to interact with future lighting systems, and illustrate this vision with a few concepts implemented in a living lab environment.

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. During the paper presentation session, we had lively discussions and interactions about the subject. These discussion and interaction continued during and after the lunch.

In the afternoon, we collected all cards (±150) with the keywords that participants wrote. An extensive and in-depth discussion followed to cluster the cards and create a common view on the research field. The physical cards proved to be very useful tools. These helped to keep focus, to centralize the discussion, and to create a visual group

mind map. The cards could easily be moved around which facilitates clustering and making connections between words. Furthermore, participants could easily take turn in the discussion by grabbing a card.

Figure 2 visualizes the results of our afternoon exercise. The words in the circle represent the key topics of the field of Interactive Ambient Lighting. Words outside of the circle represent adjacent research communities, such as Human-Computer Interaction, Ambient Intelligence, Embedded Lighting technology, etc.
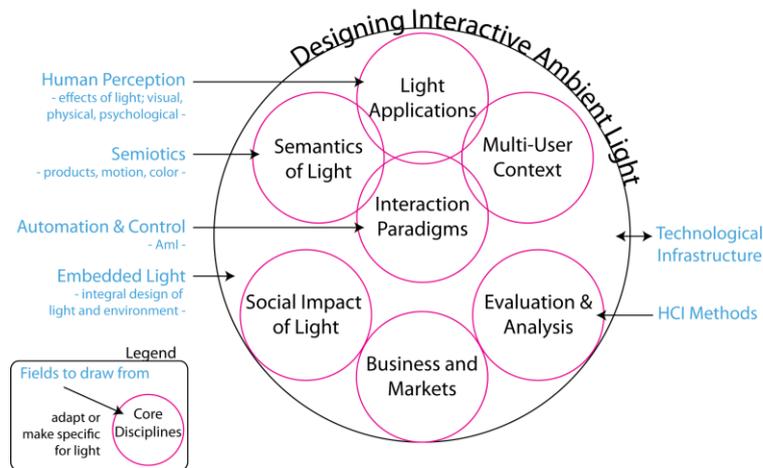

Figure 2 Our view on the Interactive Ambient Light field

Future work

During the workshop we have only outlined the field of Interactive Ambient Lighting. As a follow up, we plan to organize workshops that will focus on a specific topics identified during the workshop. We would like to thank all participants of the workshop for their enthusiasm and valuable input.

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