Interactive Visible Light Communications: Using Human-Light Interaction in Learning Contexts

Jari Laru, Faculty of Education, jari.laru@oulu.fi
Marcos Katz, Faculty of Information Technology and Electrical Engineering, University of Oulu, marcos.katz@ee.oulu.fi
Sanna Järvelä, Faculty of Education, University of Oulu, sanna.jarvela@oulu.fi
Juha Häkkinen, Faculty of Information Technology and Electrical Engineering, University of Oulu, hakki@ee.oulu.fi

Abstract: This paper describes a conceptual framework about the exploitation of light in a novel and integrated manner, using a solid-state lighting infrastructure to provide wireless connectivity, illumination as well as advanced ambient intelligence. These capabilities are achieved by using lighting sources made of light emitting diodes (LEDs). The fact that LEDs can be easily controlled brings another dimension to the proposed concept, as the light sources are used to provide visual signaling in the space-time-color and intensity domains. This will allow embedding intuitive visual information to users to enhance social interaction, orchestrate activities and manage learning situations.

Keywords: light emitting diodes, visual light communication, human-light interaction, learning cube

Introduction

Our paper is a future-looking initiative focused on the use and exploitation of solid-state light in novel ways. (Nakamura, 1997; Pimputkar, Speck, DenBaars & Nakamura, 2009). We aim to use of visible light as a way to provide wireless communications. As such it is a promising and novel approach complementing radio technologies in a variety of uses and scenarios. This aspect is known as Visible Light Communications (VLC) and it has not been studied extensively yet as it is a rather novel concept introduced approximately in year 2000 (O’Brien & Katz, 2005). However, we believe that this approach can be enhanced and extended by adding new dimensions to the concepts of VLC. We propose the concept of interactive visible light communications (iVLC) as an integrated solution providing (optical) wireless connectivity together with energy-efficient illumination, as well as intuitive ambient intelligence and social interaction.

Smartbeams: Multiple dimensions of light

The iVLC concept uses beams of light generated by solid-state sources. Light beams capable to generate light that can be exploited in multiple dimensions are called smartbeams in this project. However the lighting elements need not to be necessarily arranged as a two-dimensional regular array but they can be in fact in any position of a three-dimensional space. In practice lighting elements could also be on the floor, walls and integrated into furniture, appliances and objects, for instance. As human being are the ultimate beneficiaries of the light, we define this interaction as Human-Light Interaction (HLI).

In short, human-light interaction defines how certain target actions are mapped into light outputs. A target action is a desired activity or situation an actor wants to achieve. For example, an act could be an elaborated succession of activities defining for instance certain orchestration. An actor is a person, a group of persons or a machine, local or remote, managing or controlling a space with people. A target action could be for instance broadcast certain information to people, provide visual guiding, orchestrate a situation, create a particular mood, illuminate the room, display a graphic symbol or icon (still or moving), send data to a particular device or group of devices, etc. It is important to note that several target actions can be realized at the same time, for instance, while illuminating a given scenario, the system can also provide data coverage as well as produce visual signaling in the time-space-color-intensity domains.

Lightcube as a conceptual tool for human-light interaction

LightCube (figure 1) is a conceptual tool for learning contexts. It is a cube where each of its faces can be used for sending and receiving data information through light while at the same time each face can change color and intensity as a way of signaling visual information. LightCubes can be made small and portable, to be used as personal information hubs, and also they can be larger in size to serve as a hub for several people in a given space. For instance, in a classroom each student could have a LightCube serving as a hub for interacting with
other actors around him or her. The upper face of the cube could serve as a visual student-teacher interface whereas the left and right faces could visually connect the student with his or her immediate classmate.

**Figure 1.** The concept of LightCube

**Human-light interaction scenario in a learning context**

This scenario is based on three design principles for supporting socially shared regulation (Järvelä & Hadwin, 2012): awareness, externalization and prompting regulation (Järvelä, et. al, 2014). The classroom is illuminated by inexpensive and very low-power consumption solid-state lamps, a prevailing green attitude of the time. Students in the classroom use portable devices (e.g., tablets) including lightcubes (described above) as learning tools. Teacher uses ceilings lamps, cubes and VLC equipped furniture for orchestrating (Dillenbourg, 2013) teaching and learning activities. She/he will start by having whole class session in which learning materials are broadcasted on the devices’ screens as the teacher goes through the agenda of the following groupwork and introduces the topic. During the class students can externalize their emotional, motivational or cognitive states by using the LightCube. As light wavelength (i.e., color) of ceiling lightning and lightcubes can be dynamically tuned, appropriate ambient atmospheres will be created in response to students’ cognitive, emotional or motivational states. Light is used in the classroom for carrying all required information, namely data to/from the wireless VLC devices and visual intuitive information to the students’ eyes. Because VLC connectivity is based on light, classroom is equipped with activity specific VLC tools: e.g. homework synchronization hotspot and groupwork table with special data areas. In sum, light is used in this classroom to guide and support, in a natural and simple fashion, all classroom activities, orchestrating intuitively actions such a class workflow control, guided collaboration and teamwork, timing and order management, group formation and others.

**References**


