# Light Pointer

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**ABSTRACT**
With the more common practice of controlling indoor lighting remotely instead of by direct wiring, and increased flexibility of lighting parameters (intensity, colour), there is a need for new interfaces and interaction paradigms. Using a spatial gestural interface based on a laser pointer and sensors with multimodal feedback (light, sound and touch) an intuitive and engaging interaction style has been designed, as a first exploration of a the development of a interaction infrastructure for lighting control.

**Author Keywords**

Lighting control, Interaction Infrastructure, Laser Pointer, multimodal feedback

## INTRODUCTION AND BACKGROUND

Traditionally light control in home and office environments takes place through switches (on/off), dials and sliders (dimmers), and sometimes motion sensors. These controls can be incorporated in the built environment such as walls, or be attached to lights that people place themselves (desk lamps, bed side lights). This often leads to a jumble of controls each with their own location, interaction style, and focus.

There is a need for a unified and integrated control system, however the light interaction should be intuitive, clear, and allow for profound control over all lighting parameters (location, direction, intensity, colour etc) yet be easy to use. Technically such a system is facilitated by the existing lighting control systems for homes (domotica protocols such as X10), office environments (Dali, C-Bus), and theatres (DMX). On top of such a technical infrastructure we need to design interfaces that allow people to influence their lighting environment, such as explored in projects presented in several research projects such as the work by Brad Myers et al (including laser pointers)[1,2], and work on gestural and speech interaction [3,4].

In the Interactivation Studio we developed a first interface for this approach, the second author as a student intern from the TU Eindhoven Industrial Design department. The prototype was presented as a demo at the OzCHI (Australian HCI conference) in November 2011 [5].

The gestural interaction style using a laser pointer and sensors was based on earlier developments by the first author, then at the VU (Free University) Amsterdam, and a multimodal interaction design framework [6]. This new handheld interface we designed, combines a laser pointer, motion sensors and a vibrotactile actuator. The target (lamp) was fitted with a light sensor (tuned to the laser light), visual and auditory feedback.

The main goal of the project was to develop a natural and intuitive way of interaction for controlling lighting systems. A ubiquitous controller to interact with light was developed, based on a laser pointer. The system works on a network which connects different light sources in an indoor environment. Assuming such a network is in place enables us to focus on the design of interfaces, and treat the environment as an electronic ecology [7]. In such an infrastructure all home appliances are networked together, including ones that were not part of such a network before, in the Internet 0 as proposed by Neil Gershenfeld et al [8]. They propose a granularity of networking down to the individual light switches and light bulbs. This approach allows us to propose and develop whole new interaction styles. Another inspiration for this project is the work carried out at Philips in the mid 90s (which the first author was involved in) which looked at possible interaction styles for networked homes and distributed multimedia [9]. This project was a collaboration between Philips Research and Design departments, and one of the most promising interaction styles was a pointing token. This was tested with users in a test living room, with the system mocked up with existing technologies and some dedicated technology, creating a functioning system which was transparent to the user. The responses of the audience to the pointing interaction style were very positive, it was seen as intuitive (but the issue of invisibility was raised at that time too).

In this paper we present a first implementation of such an interaction style, as a first step towards a more elaborate interaction infrastructure. The nature of the research approach in the Interactivation Studio is deliberately open, inviting casual users to be involved in the design process at all times (this includes experienced design staff with backgrounds in lighting, architecture, interaction and industrial design etc.). Presenting the work in such a preliminary stage in demos (OzCHI) and in the Designing Interactive Lighting workshop enables us to gather further feedback and design input in this early stage.

## EXPLANATION OF THE SYSTEM

The interface consists of the combination of a handheld device and additions to the lighting fitting (luminaire), as can be seen in Figure 1. The handheld device contains a laser pointer, and the luminaire is fitted with a light sensor which is sensitive to the laser light. This way the intention of the user, to select a light, is detected. This event is confirmed to the user with a small light cue (red LED) and a sound cue, both from the luminaire, and a tactual cue from the interface in the hand. The luminaire is now ready to be controlled, through the motion sensors inside the device. By moving the interface the user can indicate what changes are desired, ie. turning the light on or off, dimming it, or changing colour.

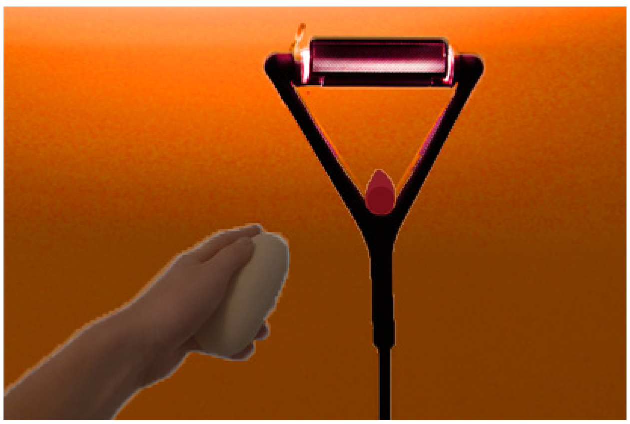

**Figure 1. pointing device and the modified Luceplan lamp**

The time the user has between activating a light source with the laser pointer and interacting with it before the light source is deactivated, is adjustable (although the user can immediately interact with the light after it is activated). This is one of the research questions, what the optimal adjustment time is. Generally it is better to avoid system determined timing in interaction, so we will try to find ways to bring this under user control by applying a subtle implicit action such as a force applied. This relates to the issue of addressing multiple lights, using a longer time between activating the light and interacting with it may give the user enough time to activate several light sources and then interact with it in one action. So far in our research the light sources are addressed individually, one of the next steps is to add a mode for grouping the light sources and interacting with them in groups (lighting zones). At this moment we try to emphasise the use of redundancy in the multimodal feedback and presentation, in order to potentially compensate for obscured cues or distracting contextual issues (in case the luminaire is not directly recognisable). More formal tests and evaluations have to be done in order to determine if this way of indicating light sources will be sufficient.

We are also considering a possibility facilitated by the integrated system, with the target areas lighting up to indicate where the sources are, in response to the user moving the controller. Other possibilities to indicate which and where the light sources in this area are located will be a map where all light sources in this area are indicated.

Furthermore we think of icons (for example 3D objects), or an 'exploration mode' where you can move through the space with the pointer and potential interaction points (like luminaires) give a multimodal and distributed cue (tactual, sound and light).

## INTERACTION MODALITIES, PRESENTATION AND FEEDBACK

Our research focused on finding the most appropriate interaction modalities in each stage of the interaction, from how the system presents itself (cues indicating interaction possibilities, which can also be called feedforward [10]), to feedback for guiding, articulating and confirming the user's actions.

With the current system the user can select a lamp by pointing with the laser pointer at a target (the sensor) attached to the lamp. While pointing at the target to activate the luminaire, the light will not go on yet. A tactual and auditory feedback cue is used at the moment of activation (which gives the user a subtle indication that something is activated) and a small LED at the target place (to indicate it is active). The lamp is then activated, which allows the user to adjust the intensity of the light (by holding a button and making a vertical movement with the controller) and change the colour (a circular movement with the controller). These movements are supported by tactual feedback, generating tangible clicks which indicate the steps of the lighting parameters manipulated, potentially improving the interaction with this articulatory feedback. When the preferred settings are reached, the user can release the button which makes the settings definite.

## TECHNICAL EXPLANATION OF THE SYSTEM

The project developed in an incremental way, over the course of several weeks of experimenting various technologies were added in order to implement the developing concepts of interaction. This meant, of course, that we ended up with an abundance of hardware and wires, but this approach supported the freedom of conceptual development we wanted. With the finished system, we are able to shrink the whole set-up into a few Arduino circuits which is the goal. As we went along, we guarded that only technologies were added that eventually would fit in this final set-up.

We started with a combination of a Phidget Interfacekit (general input/output hardware that reads 8 analogue signals, 8 digital inputs, and can control 8 digital outputs and through USB) connected to an Apple Mac running the Max/MSP/Jitter object based graphical programming language. Through the Phidget Max object we can read all inputs and control the outputs in real time. From this set-up we added elements if needed as we went along with the development. The luminaire of choice was a Luceplan Lola, a sleek and elegant Italian minimalist design standing floor halogen uplighter (the Studio has all Luceplan floor lights and desk lamps). We used an off the shelf electronically controlled on/off switch, which is a standard power board with a (radio) remote control. The contacts of the remote control were soldered to a Phidget board, with a relay, controlled by the software through the Phidget Interface kit. The light sensor on the lamp is an LDR (light sensitive resistor) with a red filter attached, to make it more reliably sensitive to the laser pointer light. An LDR was used because they are available in bigger sizes than a light sensitive diode or transistor, in our case Ø 10mm. Fluctuations in environmental light are compensated by an algorithm in the software, which looks for substantial quick changes, such as occurring when the laser pointer hits the sensor. The light sensor is read into the Phidget kit, which also controls the red LED feedback light on the luminaire. Feedback to the LED is generated in the Max programme (or 'patch'), which also generates an audio feedback cue, which is displayed by a small active loudspeaker from the audio output of the Mac and mounted on the Lola lamp.

In the handheld device, a laser pointer is mounted controlled by the Max patch through the Phidget kit output, a touch sensor for sensing the grip of the user read through the Phidget kit, a switch connected to the Phidget kit, a vibrotactile actuator connected to the audio output of the Mac, and an accelerometer. The accelerometer is a Phidget sensor connected straight to the USB, containing a 3-axis sensor, of which only two axes are used for 2 Degrees of Freedom (DoF) tilt sensing (pitch and roll, mapped to light level and colour respectively). The vibrotactile actuator is a driver, ie. a loudspeaker without a cone (sometimes referred to as a voice coil) connected to a small audio amplifier. With this technique it is possible to generate a large range of tactual cues, addressing the user's cutaneous sense.

In this stage it was not possible to control the dimming or the colour of the halogen Lola lamp, so we decided to simulate this with an electronically controlled LED Par stage lamp. This lamp was controlled through the DMX stage lighting protocol, which we linked to the Max patch using an Arduino (connected through USB) with a simple DMX driver circuit on the serial port.

The whole system was kept out of sight of the user, only the interface elements would appear to them, ie. the handheld controller and the feedback elements on the lamp. The handheld controller was first made of soft foam, to find the optimal shape by hand, and then made of urethane foam. Urethane is a hard material that can be tooled, and has a rich but not a fragile feel (it is also known as chemical wood, and known as Ureol which is a trademark of Cibatool). The form is based on the shape of the targeting point, to support the user to create a mental model of linked elements. It was made by temporarily gluing two blocks of ureol together, then creating the shape using a lathe, after which the two halves were separated and hollowed out in order to fit the electronics inside. The only concession we had to make at this point is that the device is tethered with the USB and sensor/actuator cables, in the future of course this would be a wireless Arduino / Zigbee combination.

## EVALUATION

There were two (very informal) user tests conducted (with in total about 40 people), to investigate how people interact with the system and what the effect was of the multimodal feedback.

The first user testing moment took place in the Interactivation Studio during a public event, where several students and staff members interacted with the system (around 10 people). The controller was made of foam with sensor (for activating the laser pointer) and button (for interacting with the light) on the outside. The model was too fragile, but reflected the places where people held the device. Based on their feedback the sensor and button were slightly relocated.

The second user testing moment took place at the OzCHI conference (Canberra, November 2011) where this project was presented as a demo, the controller made of urethane, and the sensor and button placed within the surface of the model. In general people had no difficulties with targeting the laser pointer within an acceptable amount of time (3 seconds). The sensor to activate the laser pointer was in most cases hit by chance, when grasping the device (which fits the purpose). When asked to change the intensity of the light, most people first looked curiously at the controller and shook with it, where after they found out it worked by making up/downwards movements.

In terms of feedback most people were aware that there was a sound click when pointing at the LDR and light from the LED slightly under the target. The vibrotactile feedback for adjusting the intensity was not felt by everyone (it was subtle) but liked by others for the fact that they could actually feel the steps they made to adjust the intensity. The spectrum is used as starting point for adjusting the colour, however it should be tested if this is the most intuitive way, or if there are more intuitive ways. The same goes for the interaction with the intensity parameter.

### CONCLUSION AND DISCUSSION

The outcomes of the project are preliminary and there is still more research to be done, this phase of the project was deliberately kept simple to strongly engage with the basic interactions. Most important (albeit preliminary) findings are that the audience seems to have a preference for the use of a tangible device over other gestural, or speech controllable devices; the ability of the audience of hitting the target with the laser pointer seemed sufficient, and a general positive response to the interaction with the controller and the effectivity of multimodal feedback when interacting with the system.

For further research we have identified the following main questions and tasks:

- To what extend do people appreciate pointing as an interaction style.
- Whether a pointing based system is easier to use than existing interaction (switches and dimmers).
- To determine the optimal target size. This extends Fitt's law of movement versus target size, as we often don't know where the luminaire will be placed the distance is not known, and we don't know if the users will employ their whole arm or just their wrist to achieve the movement. The target size has to accommodate all possible behaviours. It possibly needs to be dynamically scaled, depending on position and learning curve.
- Identifying which motions are suitable to map to parameters of light: possible motions are gestures, but also pressure, squeezing, etc., mapped to lighting parameters such as intensity, location and colour.
- How can multiple light sources be addressed simultaneously, with presets (programmed in a different mode of interaction) or compound movements?
- Furthermore, how can this approach be integrated in a control system which includes other parameters of the home environment, such as temperature, air flow, natural light (shutters etc.), and media such as music and video?

The interaction styles we are investigating and designing may work redundantly, even retrofitted and co-existing in current implementations (of hardwired systems). As with any remote control, we don't want to be left in the dark when the remote control is lost.

One important goal for us with this work is not just to make lighting control easier, more intuitive and more effective, but also to lead to reduction of energy consumption.

The approach in the current stage is aimed at retrofitting in exiting situations, but the overall aim of the project is to develop interaction styles that benefit from the possibilities of new infrastructures. In fact the design of infrastructures in future buildings could be driven by the possible interactions identified in projects such as these.

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