
LUTRON

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Rethinking Our Interactions with Light

Insights

- The light-emitting diode (LED) has allowed for the emergence of new functional and expressive ways to use light.
- The traditional light switch does not allow for the control of increasingly rich and complex lighting systems.
- We must tame this complexity and provide means for people to interact with light in simple, rich, and accessible ways.

IMAGE BY SCOTT ROBINSON

We human beings have come a long way since our prehistoric ancestors gathered around a fire some 1.5 million years ago for company, protection, cooking, and warmth. Besides all its wonderful newfound benefits, fire also offered the first means to extend the day into the nighttime hours by providing a source of light. When the Egyptians created the first wax candles 5,000 years ago, we also then had a convenient way to control and carry light with us. In the late 1700s, oil and gas lamps became common for indoor use but were used for only short amounts of time due in part to the risk of carbon monoxide poisoning. Then came electric light (Figure 1), which has had a profound effect upon our modern-day society.

The invention of the incandescent light bulb is commonly attributed to Thomas Edison in 1879. Although other inventors had earlier devised different incandescent lamp types, it was Joseph Swan who patented the idea of using electricity to heat a carbon filament white-hot inside a partial vacuum, for which he obtained a U.K. patent in 1860 [1]. Edison later developed Swan's invention by making it more efficient

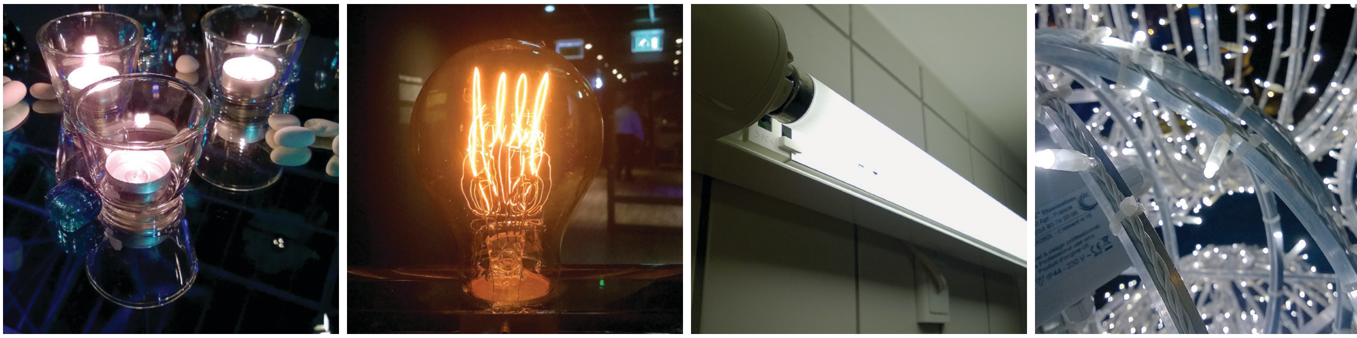

Figure 1. Different light sources. From left to right: candles, an incandescent bulb, a fluorescent tube, and light-emitting diodes (LEDs).

and commercially practical via his designs for an electricity distribution network. Swan sued Edison over patent infringement and won, resulting in the merger of both companies into the Edison & Swan United Electric Light Company (commonly known as Ediswan). Incandescent light bulbs are highly inefficient; only 5 percent of the electrical energy used is converted to visible light. The remaining 95 percent is emitted as heat.

Founded by Edison, General Electric began the commercialization of the first fluorescent tubes in 1938, making them widely available to the consumer market in the 1950s. Fluorescent lamps consist of a glass tube that is filled with mercury vapor and has an internal phosphor coating that emits visible light when struck with ultraviolet energy. Because of their higher efficiency—25 percent compared with the light bulb's 5 percent—and affordable price, fluorescent tubes became the mainstream lighting technology in homes, offices, and public buildings [2]. In 1980, Philips began producing the first compact fluorescent energy-saving lamps, and a decade later came recyclable lamps with lower mercury content.

Due in part to its key properties of being digitally controllable, physically small, highly energy efficient (30 percent), cheap to manufacture, simple to maintain thanks to its long lifespan, and able to create a variety of colors, the light-emitting diode (LED) has revolutionized the lighting industry. The invention of the LED is credited to three people: Oleg Losev for constructing the first LED in 1927; James R. Biard for producing the first infrared LED in 1961; and Nick Holonyak Jr. for the first visible red LED in 1962. LED lamps produce light by a flow of electrons across a band gap in a semiconductor, and color is determined by the energy band gap of the semiconductor. In 2014, Shuji Nakamura and his team received the Nobel Prize for Physics for the invention of the blue LED in 1995. The blue LED, when used with a phosphor, has enabled LED-based white lighting, which is rapidly replacing incandescent bulbs and compact fluorescent lamps.

FROM LIGHT SWITCHES TO REMOTE CONTROLS

Our main way of controlling electric light has been through our interactions with light switches (Figure 2). Light switches have been around since 1884, when John Henry Holmes invented the first quick-break technology switch. In 1917, William J. Newton invented the toggle light switch that produces an audible snap or click, followed in 1959 by Joel Spira's dimmer control that allows people to change the brightness of light, string-actuated pull switches for use in damp environments such as bathrooms, and the now pervasive rocker switch barely protruding from the wall that acts like a seesaw: When one side is pressed the other one rises. More recently, different electronic switch types that use touch-sensitive plates, soft buttons, and even interactive touchscreens have emerged [3].

Some light controls are supposed to require no explicit interaction at all, such as motion detectors, also known as occupancy or presence sensors. However, many of us have been in the situation at a residential or public toilet where an intelligent lighting system decides that you have spent the required amount of time in there and automatically switches off the lights. While we may resort to slightly tilting our heads to activate the motion sensor, in other cases more wild and exaggerated arm movements are needed. Is waving our hands in front of sensors how we are expected to interact with lighting—or, for that matter, water faucets and soap or paper towel dispensers—in this modern world? For all the progress we have witnessed in lighting technologies, in terms of interaction we seem somehow to be highly attached to the good 'ole light switch. Is the light switch therefore an example of perfect design?

In 2004, we first experimented with remote controllers to interact with electric light [4]. In particular, we used a handheld mobile device—called a Pocket PC back then—and its wireless connectivity capability

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Figure 2. Current ways to interact with light. From left to right: a string-actuated pull switch, a rocker switch, an electronic switch, and an integrated motion detector.

(Wi-Fi) to control an advanced bathroom system consisting of 50 different light sources and inspired by the traditional light switch. Using their fingers, people could control different groups of warm and cold white lights by switching them on and off and dimming them (Figure 3, left). In addition, using a simplified representation of the bathroom layout, people could also spatially position and dim groups of colored lights (Figure 3, right). In 2012, Philips introduced its Hue lights, which combined state-of-the-art LED lighting technology with a smartphone control, allowing people to wirelessly control the lights via an app. The Hue system allows people to decide between one of its many preset scenes and having full control over color and brightness to create lighting moods. Fagerhult's e-Sense Tune automatically detects people's presence using the Bluetooth signal of a smartphone, delivering your preferred lighting setting as you enter a room. So we have now added the use of a device that many of us carry in our pockets to control lighting at home and in our offices. But are there simpler, perhaps more intimate ways to interact with modern lighting?

TOUCHING LIGHT DIRECTLY

Until recently, directly touching electric light with your hands was really not advisable. Most of us have had to wait for a light bulb to cool down before removing it or risk a nasty burn. But unlike incandescent bulbs, LEDs are mostly cool to the touch, which has opened up new opportunities for interacting with light through direct manipulation with our hands (Figure 4). In addition, thanks to their small size, LEDs can now be embedded pretty much everywhere. But could we somehow regain the ability to carry light with us, which portable wax candles provided back in the day?

With Light Bodies, Susanne Seitinger and her colleagues have explored just that by allowing people to modify their personal "lightscape." Light Bodies [5],

Figure 3. A light switch using a handheld mobile device to control groups of warm and cold white light (left), and to spatially position and dim groups of colored lights (right).

Figure 4. Children experiencing light and sound in harmony, while using their hands to directly touch light at the Kolding Light Festival in Denmark.

Figure 5. Translucent acrylic cases fitted with 20 colored and white LEDs each, a microphone and a vibration tab, which allow people to modify their personal "lightscape."

Figure 6. Lighting reacts to people's movements in the *Interference* light tunnel in Kolding, Denmark.

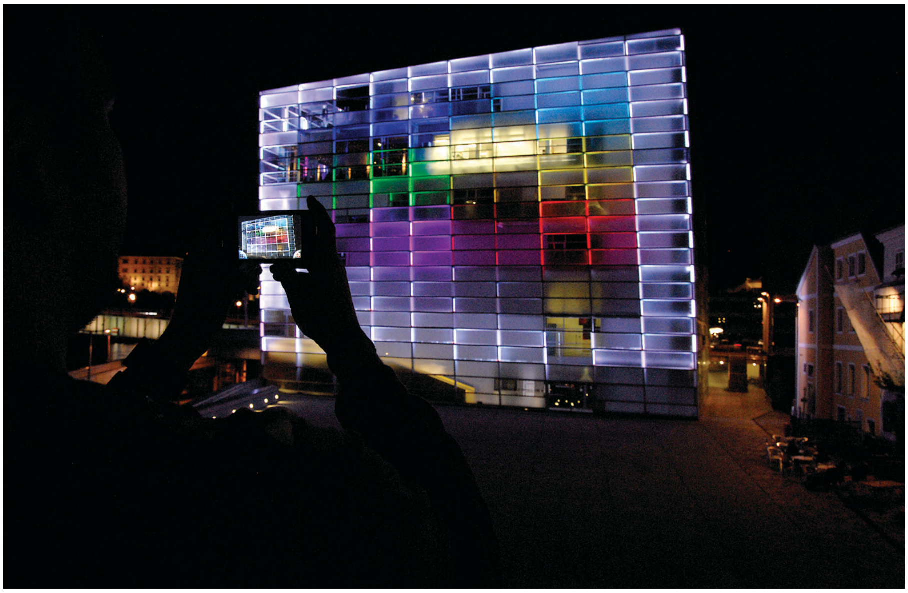

Figure 7. iRiS uses live video to allow people to interact with a media facade.

mobile handheld lights that respond to audio and vibration input, were used to investigate the relationships between spaces and personal lights. Translucent acrylic cases were fitted with 20 colored and white LEDs each, a microphone, and a vibration tab (Figure 5). The Light Bodies were deployed during three performance-like settings where people interacted with them in different ways (e.g., by shaking, tapping, arranging, blowing on, or singing to them). In dark conditions especially, personal light devices such as Light Bodies or handheld pico projectors can also be used as flashlights and generate dramatic lighting and shadow effects that can be used for expressive interactions. Others have explored similar uses of light by embedding LEDs in wearables or by weaving fiber optics into carpets and even clothing.

We have briefly discussed how to interact with lights that are in close proximity to our bodies. But what about when the scale is large? How do we interact with light on a building, or even on a city-wide scale?

LARGE-SCALE INTERACTIONS WITH LIGHT

In urban and city contexts, modern lighting can be applied to serve social needs in fun ways. For instance, Kollision's *Interference* installation in Kolding, Denmark (Figure 6), is a light tunnel that uses different white-light patterns to draw you in. The tunnel activates the moment you walk in, sensing your presence and dynamically presenting different-colored light patterns. It acts as an extension of you, connecting you to the space, as if the tunnel were walking alongside you. Though you may try to outrun the light, it will always be with you, like your shadow. Interesting lighting patterns emerge as people try to cross the tunnel in opposite directions, each at their own pace. This permanent installation helps tunnel users to feel safe and engaged with their town all through the year.

With widespread mobile Internet coverage and the majority of citizens carrying smartphones, even collaborative interactions with lighting are possible. Have you ever wondered about painting a building

FIGURE 5 IMAGE BY SUSANNE SEITINGER, THE TATTOOED TENTACLE FIGURE 7 IMAGE BY MARTIN KNOBEL with light? iRiS [6] allows people to collaboratively (or competitively) interact with a building facade using their mobile devices. Visitors to this installation at ARS Electronica Center in Linz, Austria, can *paint* light with their fingers by aiming their smartphone at the facade and observe the results on the building via live video. An app allows them to *point through* the display, giving the impression of directly touching the building (Figure 7). Similar forms of *participatory lighting* that invite people to create with light in urban environments should be explored further.

CHALLENGES AND OPPORTUNITIES FOR INTERACTING WITH LIGHT

In a series of workshops on interactive lighting, we identified several challenges and opportunities for interactive lighting [7]. Here, we have mostly discussed situations where people (in)directly control and play with light. However, light also affects us psychologically and biologically, and can thus be used to influence people. Biodynamic lighting that imitates spectral and intensity changes of daylight can be used to influence our biological and psychological processes, as well as our well-being, mood, and performance. As we gain more understanding of the importance that light has on how we function and behave as humans, and the potential manipulative powers that lighting can have, several ethical issues arise: Who should be controlling such lighting systems? What are suitable contexts for such lighting to be applied? Offices, schools, urban environments, crowd control? Can one simply refuse to be influenced by light?

The omnipresence of light in shared spaces leads to questions of multi-user interaction. How can we provide individuals with the means to interact with light, while at the same time preventing potential conflicts with other collocated people? Can we strike a balance between personal and collective lighting interaction preferences or come up with a democratic lighting control? Is providing partial light control automation the only way to avoid transferring interaction complexity to people? By closely looking into people's needs and specific use contexts, we can better understand issues around the semantics of light, or how people interpret light in different situations.

Light can also be used as an effective information carrier in many applications for communication, guidance, and safety. However, as we enter the realm of glanceable ambient devices and displays, new design challenges arise. The legibility of information is closely related to cultural and personal interpretations of light, as well as to meanings of light in different contexts. In addition, there is a risk that the increasing abundance of information in the form of controllable colorful lighting will eventually blind us or make us illiterate to crucial visual information in certain environments.

OUR FUTURE INTERACTIONS WITH LIGHT

LED-based lighting is providing new possibilities that were simply not possible with traditional lamp technologies. All this new functional and expressive potential comes at the cost of increased complexity for everyday people in terms of controlling these advanced lighting systems. The traditional light switch does not yet allow us to easily control color, brightness, or dynamic spatial patterns with multiple light sources. Replacing light switches with smartphone apps largely remains somewhat of a niche market—something for people who have the interest in exploring new technologies and who can afford pricey gadgets. As LEDs become widespread around the world, it is our responsibility as interaction designers to devise ways to tame this complexity and provide the means to play with and enjoy light in simple, rich, and accessible ways.

Endnotes

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