User Interfaces for LED Lamps

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From billboard-sized video screens to car break lights, bright LEDs are put to use in a variety of applications where conventional projection and incandescent light sources have prevailed for decades. Their energy efficiency, space and production economy and ability to emit light at high brightness makes them possible candidates for replacing traditional lighting technologies. In addition to replacing their incandescent counterparts, LEDs lend themselves to a new exploration of lighting possibilities, including control of color temperature through versatility in LED colors and computer-controlled lighting by networking embedded LED fixtures.

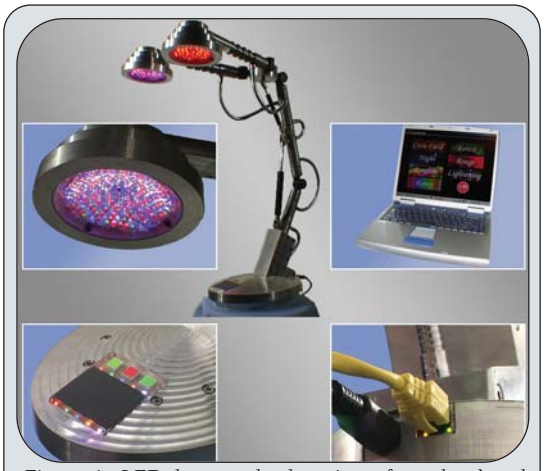

Figure 1. LED lamp and adaptation of touchpad and network technology in lighting control.

To experiment with LED technology for lighting and novel user interfaces for their control, a LED desk lamp with two light fixtures has been developed. Each light fixture contains 252 bright LEDs of five distinct colors arranged hexagonally in a concave dome. Three opponent color pairs originally described by Ewald Hering in the late 19th century inspired the selection of red, green, blue, yellow and white as component colors for the LED fixtures. Conventional lighting controls do not interface well with the design of the comparatively large cluster of discrete light sources. Uncomplicated and fast selection of parameters for area lighting are necessary for typical light-switch-like usage, while flexibility of control is desirable for custom applications. These two approaches, a touchpad and a network-based control for LED lighting, were introduced to meet these demands (Fig. 1).

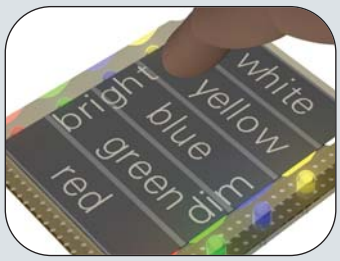

Figure 2. Using virtual vertical sliders: the touchpad is divided into five vertical regions, each of which controls one color. To increase the intensity of a color, the finger is moved towards the top of a slider.

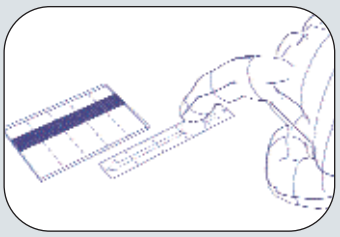

Figure 4. Interaction technique for adjusting multiple colors at (almost) the same time: instead of moving several separate mechanical sliders, horizontal movement of the fingertip over the touchpad spans multiple virtual sliders.

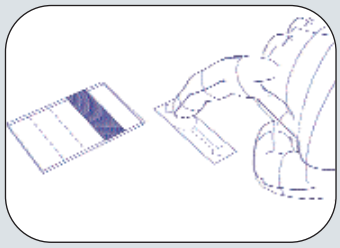

Figure 3. Interaction technique for a Slider or Knob found in dimmers: the vertically moving fingertip replaces mechanical pegs in potentiometers.

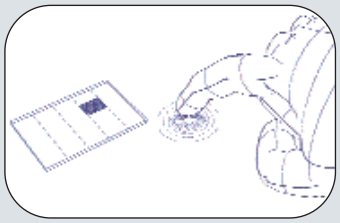

Figure 5. Interaction technique for adjusting light spread. Intensity of finger pressure on the touchpad controls the dimension of light spread for a given color at a given brightness.

Conventional lighting parameters are controlled from a generic capacitance-based touchpad. Interaction with the touchpad is modeled primarily after common functions of light switches and dimmers. Additional functionality is derived from the benefits of a touchpad's second and third dimensions, which are not present in ubiquitous light controls. These dimensions are used to encode variability of color and light radius in the large multi-colored LED fixture. The two-dimensional touchpad surface is divided into five virtual sliders, each representing one color (Fig. 2). Effortless movement of the finger over the touchpad changes the lighting environment. To change the brightness of a color, the finger is moved vertically over the touchpad; brightness increases towards the top and decreases towards the bottom (Fig. 3). To turn on all colors at the same brightness level, the finger is moved horizontally over the touchpad at the desired vertical position (Fig. 4). Besides the light intensity and color, spread of light from the LED fixture is a further dimension that can be controlled. Selections of LED clusters between the fixture's center and its outermost rim generate various desired light spread values. Typical touchpads measure finger pressure on their surface, a value that can serve as an indicator for the spread of light (Fig. 5).

Lighting controls for customized applications are implemented through an embedded network module, which connects the LED lamp to a standard TCP/IP network. Simulations of lighting configurations in software can be mapped onto the light fixtures in real-time. The network interface accepts short text messages, which control individual or groups of LED clusters at discrete intensities. Four-character messages encode fixture address, color, cluster/group, and brightness. The present prototype can process up to 50 network lighting events per second.

A software tool provides several sample control configurations for the LED fixtures. The application features themes for mood lighting, sound-controlled lighting based on spectral analysis and manual control over individual clusters. Other potential applications include external sensor-based inputs by which the LED lamp assumes the purpose of an indicator in addition to its primary function of lighting. Natural occurrences (external temperature change), local activity (door bell ring, e-mail arrival) and news events (stock market) are examples of indicators that can be easily modeled.

This is how a standard touchpad unit can be used for conventional lighting control by superimposing five virtual vertical sliders onto its surface. It is possible to implement three separate dimensions of control: light intensity, color and radial spread of light. Through informal, but extensive user studies under real-world conditions with more than 300 users representing all age groups, positive feedback and acceptace of this idea has been collected. This novel approach to providing programmatic custom control using a generic network interface shows how the LED lamp can interface with other devices.

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