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SMART STREET LIGHT WITH CAPABILITIES BEYOND INDUSTRIAL STANDARDS

The street light presented here combines conventional and traditional elements of public lighting based on proven design and technology with modern illuminants controlled by computation. By utilizing all technologies at hand the goal is just not illuminating public spaces, which is defined by the conditions of an industrial standard, but to explore the capabilities thereof. The result is a prototype that merges simple illumination and sophisticated colorful installation into one device.

INTRODUCTION

The project presents a prototype of a street light installed in a second-hand enclosure. The created device integrates different types of light sources and sensors into a state of the art smart street light, that combines environmental stimuli detection with directed lighting and an animated installation.

Keywords:

Microcomputer, Complex Lighting, Sensors, Street Light

Fig. 1. Dual nature of a smart street light.

Source: Author's own work.

As a prototype it demonstrates a possible link two different concepts or systems of lighting.

Lighting Systems

Lighting systems to illuminate public open spaces are categorized in two distinctive groups based on their appearances: The vast majority are functional lighting systems with blanket coverage comprised of white light sources as substitute for daylight. The typical case is a permanent public street light system build of stationery luminaries on an underlying regional grid.

The other group are colorful lighting installations, sometimes labeled as sculptural, artistic or theatrical lighting. They are usually temporary and designed for special places. The intersection between both groups is, for a variety of reasons, rather marginal and therefore should be addressed.

Conventional Street Light

The historic luminaire, as we all know it, is just a lamp with two states, on or off. It is powered from sunset to sunrise at full strength through out the night, even when nobody is around, and it is turned off otherwise. Commonly these lamps are grouped and controlled by a single switch, triggered by a timer or a light sensor. This scenario is still accepted for the majority of public street light systems.

Intelligent Street Light

In recent years, the manner of illumination has changed. With the introduction of new technologies like solid state lighting, especially with LEDs (light emitting diode), more differentiated sensors and network connectivity a single luminaire becomes controllable both individually and as part of a network. The individual street light, on which the public systems are based on, is drastically improving. The standards of public lighting are switching from simple on-off system based on a grid to more sophisticated adaptive systems.

A typical modern smart street light is equipped with LEDs, sensors and maybe micro-controllers to create new lighting pattern based on individual needs. Their main advantage is the reduction of power consumption, but also maintenance costs, reduced light pollution and safety issues. LEDs by themself are very energy-efficient, and the utilization of local sensors to detect if a lamp has a recipient can save even more both in terms of cost and the lifetime of the bulb.

Street lights with LEDs just as simple replacements exclude almost any possible progress. Not do they not provide any mentionable improvement, they waive all possible advancements of the technology itself.

Lighting Installation

With the introduction of LEDs colored light installations have become widespread. As result of their inherent mode of operation, their handling of colors is quite simple. LEDs always have a single color, but due to their small footprint they can be grouped. Then colors can simply be added as part of the group of diodes.

Before that, the white light from filament lamps was passed through filters to get one single color. Changing colors was rarely smooth.

In addition, more powerful LEDs have become available and, with it, the instruments to control them. Colored LEDs have already become the basis of modern lighting installations with rapid changing vivid colors.

BUILDING THE LUMINAIRE

Usually street lights are off-the-shelf industrial products. Even smart street lights, although individually controllable, are designed for mass production. With the advancement of small programmable micro controllers, high power LEDs and 3D-printing, common items and techniques from the maker culture, this assumption has become obsolete. It is possible to make a smart street light at minimal costs on your own.

Maker Culture

As already stated a combination of both concepts is not on the short list of the manufacturing industry. They are solely focused on traditional lightening and brightening. Hence other means have to be employed to create a device that serves both illumination and installation.

To build a prototype, techniques from the maker culture are adapted. It is a form of both rapid prototyping and custom made objects or things. The defining characteristic is its dedicated hands-on approach. The maker culture is a technology driven DIY-culture (Do-it-yourself) based on “electronics, robotics, 3D- printing, and the use of CNC tools, as well as more traditional activities such as metalworking, woodworking, and traditional arts and craft” [1].

Concept

Incorporating the two different concepts into one single lighting device was the main task. To control several different sources the conceptual layout follows the rule of a channel design.

A single lighting source, be it a white lamp for directed light or a color channel as lighting component of a colored light, is controlled by one output channel. As results all lighting sources are individually accessible and controllable by one computer, which should be a micro controller with hardware-channels. In addition, some channels should be available for sensors. Hence, the number of channels is only limited due to hardware constraints.

The same concepts is applied to the sensors as input channels. While it is contemplated, that all kind of sensors might be useful, most important are light-sensitive sensors to switch the device on and off and to regulate the amount of light to be generally disseminated, and motion sensors to detect the presence of people and to regulate the actual needed amount of light. The lamp as simple functional street light should only work if it is dark and if people are in its proximity.

The installation, which is conceptual unrelated from the functional elements, is comprised of the three color channels of an RGB-LED. They are controlled programmatically and can be combined into a larger installation. Hence some computational connection or network should be established.

Arrangement

For functional and directed lighting three white LEDs are used. They are arranged horizontally to illuminate sectors at 120 degrees each around the street light.

Three equally arranged motion sensors cover the same area. The matching constellation enables a fine-grained detection of pedestrians, bicycles and cars in order to illuminate their localization and their projected path. Additional sensors like temperature or noise sensors can be applied.

For the dissemination of colored light a single RGB-LED is implemented. In combination with a fitting reflector this system allows for almost infinite variations. The colored part of the street light source disseminates vertical against a reflector to produce equally bright colors to all directions.

Without protection high-power LEDs can potentially cause damage to the retina. Hence the casing of the used old street light is used to diffuse the very bright disseminated light in order to eliminate any possible risk.

In total the configuration of the street light presented here claims 6 controllable light channels as output channels and another four, three for the motion sensors and one for the microphone, as input channels. This is about between a half and 2/3 of the capacity of a typical micro controller.

Construction

As groundwork the disassembled enclosure of an old mushroom shaped street light is employed. It provides both the necessary space for the technology and the accepted iconic shape of a traditional street light.

All LEDs are individually mounted on heat sinks. According to the technical data the small ones are sufficient for the white LEDs, while the RGB-LED require a larger one. The contacts of the LED have to be soldered to a wire. This part is not really the work an architect is used to, but given the enormous savings it is beneficial, besides the fact that such a layout is not available at all and has to be custom-made by some manufacturer. The almost same procedure would deliver a device at more expenses and lesser degree of flexibility. Regarding the eventuality of installing and testing different sensors the same notion is even evident.

Altogether there are about 4 layers of construction. Underneath the corpus the three motion sensor are mounted on a platform. The bottom of the case is used for the main installation, power supply, central micro controller, the LED-channels' controllers and additional sensors. The next layer in the center of the corpus, at the very same place the removed light bulb was located, is a cylinder on which the three white LEDs are mounted. These light sources are disseminating horizontal in a slightly downwards direction.

The remaining space in the upper part of the enclosure is reserved for the upwards beaming color LED with its big heat sink and its reflector on top of it.

Tests as Installation

All controllers are connected to an ac to dc converter power source which is connected directly to the power line with high voltage. An initial test without the enclosure demonstrated some initial results. The light of the LED was reflected and its color could be observed by the reflection of the white wall. However, without eye protection it is almost impossible to observe.

Then, with its casing, the color of the LED is presented by the encapsulating diffuser.

Additionally, a microphone and a temperature sensor have been tested with the prototype. Especially the sensing of noise in combination with the presence of people can produce some interesting effects and transform the street light into a sophisticated installation.

The final test arrangement loops through all rainbow colors at an interval about a minutes. As simple demonstration it points towards the capability of the lamp to show all colors at any time frame.

Communication

Communication is one of the main feature a smart street light should provide. This refers both to the relation user-machine, as between a pedestrian and a street light, and machine to machine, as between two or more somehow related different smart street light with fully configured sensors.

In case of the user-machine communication a simple Bluetooth interface is installed and provides initial results. It is contemplated that an upgraded interface enables a communication channel to mobile phones and hence opens the lamp for interactions with nearby users.

In case of communication between different devices and maybe some controlling servers all related lamps should be grouped into a network. This can be either based on a technology named power line, where the signals are transferred through the existing power lines via an overlaid Ethernet connection, or based on a mobile telephone network. Both systems have their advantages, but also drawbacks.

Because by now only one single street lamp has been built, this task is left for some future studies with more lamps, probably more users and maybe some remote computers as dedicated servers. The main problem is neither the technology itself, nor is it the funding but the space where a couple of such lamps could be installed and tested.

SUMMARY AND OUTLOOK

While the concepts of smart street lights are evolving, the single purpose of all lighting installations being a piece of art is mostly neglected. Commonly, colorful lighting installations are not regarded as part of a public street light system. If such a system is installed and presents itself, it is usually temporary and isolated.

On the other hand the public street light system has no means to present itself as an installation. Here its single purpose is the illumination of public spaces.

The street lights presented here, as prototype made with techniques obtained from the makers' culture, demonstrates a concept and some ideas that should be neither limited to pieces of arts nor to simple public illumination. By utilizing modern technologies, a new type of street light has been created.

Although, it has still some constraints and is by far not a typical industrial product yet, as handcrafted prototype by the means of makers, it envisions some yet unknown appearances of illumination in public spaces. It goes beyond the simplicity of just brightening places and it will go further than just the luxury of presenting art.

As a type of installation then, this kind of colored lighting is not implicitly limited to artistical approaches. Colored lights with some elaborate controls can achieve other purposes. Especially

they can signal some states of a location without the support of additional signs, like in the case of an emergency.

Building the smart street light by hand based on techniques from makers already proved to be adequate in an urban context.

Evaluating which parts of the presented prototype are valid or, as in the case of the temperature sensor, may become void, will be crucial. What features should be kept and enhanced, and what attributes could be dispensed without affecting the overall acceptance of a public lighting system will become part of a future research. and evaluation.

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