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ScienceDirect

Energy Procedia 101 (2016) 161 – 168

Energy Procedia

71st Conference of the Italian Thermal Machines Engineering Association, ATI2016, 14-16 September 2016, Turin, Italy

Integration of a do it yourself hardware in a lighting device for the management of thermal comfort and energy use

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Abstract

The article describes the application of an object, called Smart lamp, for the control of the thermal comfort in real working conditions, implemented following the Do IT Yourself (DIY) approach, using a microcontroller, low cost sensors and a 3D printer. The idea beyond the Smart lamp is the concept of smart environments in which sensors and actuators interact each other with the aim of improving the human well-being. The device that upgrades in a "smart" way a commercial desk lamp usually available in offices, allows to optimize the indoor thermal comfort and the energy consumption, by interacting directly with the heat pump. In order to evaluate in a 4-person office the thermal comfort and the energy consumption improvements due to the better management of the cooling system a Smart lamp was tested. The results showed how the application of this device effectively has optimized the thermal comfort and the energy consumption.

Peer-review under responsibility of the Scientific Committee of ATI 2016.

Keywords: open source; DIY; IoT; control system; environmental monitoring system; building automation; thermal comfort; Indoor Air Quality; Indoor Lighting Quality; energy saving.

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Peer-review under responsibility of the Scientific Committee of ATI 2016.
doi:10.1016/j.egypro.2016.11.021

1. Introduction

In the Do It Yourself (DIY) approach [1,2], the user becomes the maker of low cost and open hardware technologies [3-5] that can be applied to any technological field. Anybody at any location could carry out the principles of the DIY philosophy [6, 7, 8] through enabling technologies, for example Arduino [9] using websites like Thingiverse [10] in order to quickly share smart, low cost and DIY approach based solutions among makers. The spread of this movement has led to the proliferation of devices always connected to a communicating-actuating network, i.e. a web of objects connected to the network and interconnected to each other, named Internet of Things (IoT) [11] starting a technological revolution.

A recent field of interest and study is the automation of civil buildings for the purposes of environmental comfort control and energy saving. The application of tailored and fully customizable low-cost solutions allows both the reduction of costs in building management and the improvement of energy efficiency [12, 13, 14] and indoor comfort performances. In particular, the thermal comfort perception is a very variable condition that is influenced by several factors [15] which impact directly on health and productivity of workers: an adequate level of comfort reduces work-related stress and the risk of contracting diseases with consequent benefits in terms of productivity. However, the environmental comfort is a subjective concept that cannot be determined in advance: in this perspective it should be defined specifically for each worker. This makes difficult to combine the needs of individuals with the needs to reduce energy consumption. Through a specially conceived and constructed “smart” object installed in the proximity of the user, it is possible to manage the energy intake in relation to the real requirements of the employee. A smart object, named “Smart lamp” [16] implemented following the DIY approach, is used to perform this task.

The idea beyond the Smart lamp is the concept of smart environments i.e. “a physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network” [17]. The Smart lamp was built using an Arduino Mega board and a DHT22 sensor to detect the temperature and relative humidity, a RTC module, a led IR to connect it to the HVAC (Heating, Ventilating and Air Conditioning) system and a Bluetooth module to transfer data. An appropriately designed case was created using a 3D printer based on the Fused Deposition Modelling (FDM) technology, to accommodate the electronic components in a compact way and to replace the existing lighting system (halogen lamp) with a cold led light panel. This system is available online as an open source project [18, 19].

2. Hardware and software of the Smart Lamp

2.1. Hardware architecture

Fig. 1. Smart lamp: (a) external base with DHT22 sensor; (b) system management; (c) lamp housing with LED IR and LED module.