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Smart Bulb for IoT

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Abstract

This article describes the design of a smart bulb, conceived as one who is able to maintain, under certain variations of external lighting a desired level of illumination is presented. This level of lighting is adjustable from internet, using the concept of internet of things (IoT) to said bulb. The design consists of a programming card Raspberry pi 3, an LED bulb, and a power circuit under c programming language, a fuzzy controller is used to maintain the desired lighting level. In conclusion, it is possible to obtain a home automation system with control from internet which makes intelligent functional bulb-controlled lighting systems.

Keywords: smart bulb, IoT, Fuzzy Control, Raspberry Pi

1 Introduction

The different technological advances aimed at improving the quality of people's life are in a high degree of development and emerge new applications, permanently, to approach different tasks like in domotics area. A clear example about it is presented on [1] where electronic development cards like raspberry pi, are employed to implement an intelligent ring system, where in case that a person approaches a door, is recognized by image processing and generate thus, automatically, a ring tone or a message be sent to a cellphone for notification. In [2] is presented the design of a domestic system operated from the cell phone, which is oriented openly to allow manipulate home appliances or lighting systems, for that microcontrollers and radiofrequency systems are used to give the necessary portability

of a domestic red. In [3] is presented a similar development where instead of the microcontroller, is employed a FPGA, which is a software reconfigurable electronic card, also for light control by a cellphone. Thus, the integration of electronic cutting technologies, allow to spread and adapt low cost domestic systems in the home.
At the same time, internet has increased exponentially the people connectivity, given that each time is easier and more economical access to electronic devices with the capacity of connect to this red [4]. In such a way that providing connectivity to devices which did not have this capability before, has derived in what is called "SMART" type devices, that nowadays have applications in monitoring systems, security and home applications like opening and closing doors, lighting and heating, among others. This has led to the development of several research works to allow the interconnectivity of these devices like the communication system developed in [5], this is oriented to smart devices of domestic use.

The capabilities of the smart type devices are increasing continuously, due to the inclusion of algorithms of decision making and computational intelligence, for example [6] presents machine learning systems oriented to devices under IoT schemes. For the case is used a diffuse control system programmed in a raspberry pi, so as to the bulb manages to maintain a constant lighting level, this kind of control system is similar to the one worked on [7]. The applications of IoT devices handle a very broad spectrum, for example, in rehabilitation systems like the presented in [8].

All the above, is possible to infer that systems like the proposed on this paper, which is part of the research advances that are carried into the interior of the group related to the inclusion of intelligent systems, domestics and internet of things, contributes to the development of intelligent devices based on IoT. The applications that can be derived are found in domestic area for example like security scheme, that when the light of day is diminishing (enter the night) increase the interior lighting for give the sensation of presence inside the home. Similarly, it can apply to precision farming systems where ambient lighting must be a constant factor.

The article is distributed in five sections: in the section II corresponding to methods and materials, is presented the design of the LED bulb power system; in the section III is presented the diffused controller; in the section IV is presented the obtained results of the lighting control tests, and finally, the conclusions achieved are presented in section V.

2 Methods and Materials

In this section is presented the materials and methods employed for the development of the smart bulb, are part of it the raspberry pi, the development software of the card, the WIFI communication system and the LED bulb with its power interface, which are presented now below.
The system is based in a Raspberry Pi 3 Embedded Card, which corresponds to the

third generation of this kind of card, which can be appreciate on Figure 1. The Raspberry works under an embedded operative linux-type system called raspbian, programming code based on Python can be executed on this system and the diffuse logic tool fuzzy, which are the base of the implemented algorithms.

Figure 1. Raspberry Pi 3.

The Raspberry Pi 3, in comparison with its predecessor the Raspberry Pi 2, is mainly characterized by offering Bluetooth 4.1 modules, Bluetooth Low Energy (BLE) and WiFi802.11n oriented to Wireless LAN. Additionally, has a 1.2 GHz of 64 bits processor and four cores, 1 GB of RAM, 4 USB ports, 40 GPIO pins, a HDMI Port, an Ethernet Port, camera interfaces (CSI) and screen (DSI), as well as a groove for Micro SD card (push-pull) on which the operating system is installed. Its programming allows to develop systems with internet connection, generating direct interaction on control hardware. The application development on this card gives the possibility of use touch-screens for users on site, activation and deactivation of power systems and object recognition applications through image processing libraries and a lot more.

This card is selected because of its low cost and reduced size, at par that it adjusts to the project necessities in that it can generate PWM signals on their digital outs and I2C communication for the serial communication with an analog to digital converter in charge of read the current illumination intensity, at the same time allows the internet direct connectivity by the WIFI module that has. The out of the Raspberry, which is of low power, is sent to a power transistor module, operating between cut and saturation, which replicates the PWM signal and connects with a LED bulb without driver in order to be able to vary directly the illumination intensity with which it operates.

Embedded in the Raspberry, it was developed a connection system to and from the internet that implies the use of the WIFI module of the card, by means of a VPN connection via LogMeIn. LogMeIn is an application that allows access to a computer equipment remotely from anywhere via internet, for the case is employed the free version LogMeIn Hamachi, corresponding to a virtualization network service, that is to say, establishes a connection through the internet and simulates a local area network formed by remote computers, or as required here, between a cell phone and a Raspberry.

The VPN network is established downloading the package that is found on the LogMeIn/labs page on Hamachi for Linux section, through the link of the raspberry

ARM HF and selecting the link finished on ".deb". The Fig. 2 illustrates the established network for the connection between both equipment (Smartphone and the Raspberry).

Figure 2. Configuration panel of VPN connection.

The final scheme implemented that was employed for the validation of the IoT bulb, is presented on Fig. 3. Given that the Raspberry has a WIFI module which allows the internet connection, is the one that generates the portability of the bulb, in such a way that this can vary the location and the final application, own characteristics of systems based on the principles of the internet of things.

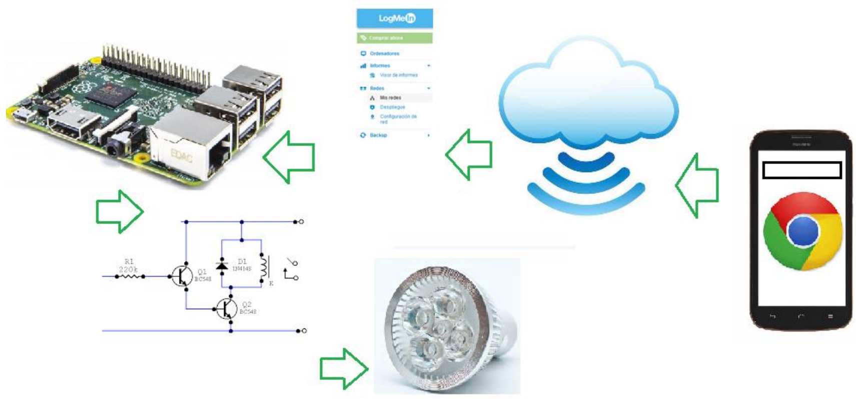

Figure 3. General scheme of the IoT application.

3 Lighting control

To maintain the desired lighting level for the bulb, compensating the environmental effects, is established a feedback control loop like is illustrated on Fig. 4. Said control loop takes the luminous intensity percentage signal desired by the remote user and compares it with the current one, the control system corresponds to a proportional-derivative (PD) diffuse scheme. The difference between the desired intensity and the current one is the input error and its reason for change over time is the derivate of said error, both enter to the diffuse system under the membership functions appreciated on Fig. 4 left part, the difference is the range or universe of speech between one and another, for the error is about -100 and 100 percent and for its derivate is about 10 percent. In Fig. 4 on the right part are appreciated the membership functions of output, which will have the task of modifying the PWM signal that increases or decreases the lighting intensity of the LED bulb.

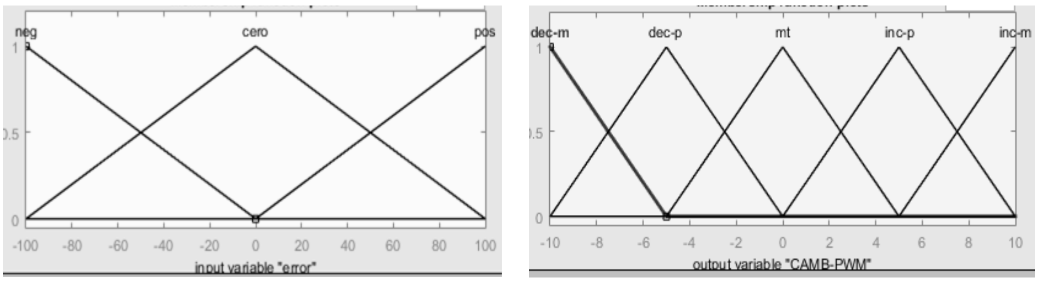

Figure 4. Membership functions of input-output.

On Figure 5, is appreciated the rule base employed, in such a way that, for each input combination, error vs. derivate, is generated an output action. That is how the case of a zero error and a zero derivate, the corresponding action will be to maintain (mt) the PWM current level that implies a zero output on the defuzzifier.

Sinal PWM		Error		
deriv_error		neg	zero	pos
	neg	dec_p	inc_p	inc_p
	Zero	dec_p	mt	inc_p
	pos	dec_m	dec_p	inc_m

pos = positive mt = keep
neg = negative
dec_p = decrement little inc_p = increase little
dec_m = decrease a lot inc_m = increase a lot

Figure 5. Rule base.

For a case like a positive error with a low magnitude derivate (close to zero), the change action of the PWM signal will be a little increase, in such a way that the change on the intensity level will be made in a slightly gradual increase. This control action is illustrated on Figure 6, where the output corresponds to a constant increase of the PWM output defunct equal to 1.57.

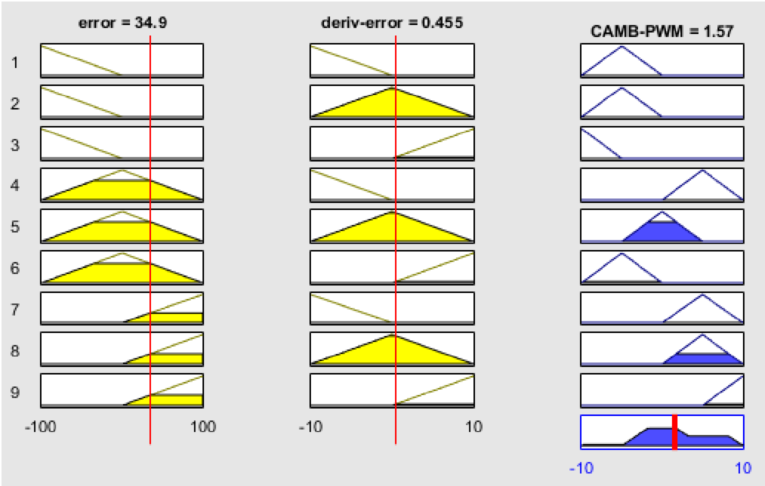

Figure 6. Rule base PWM change.

The defused output is based on the center of gravity method which is illustrated by the equation 1, this control action will allow the lighting intensity level change to the desired by the user and will cause the PWM signal change by equation 2, where the constant (2) corresponds to an amplification value and the defunct output and corresponds to the proportional derivate action.

$$y = \frac{\sum_{j=1}^{F} \mu_B\left(y_j\right) \cdot y_j}{\sum_{j=1}^{F} \mu_B\left(y_j\right)} \tag{1}$$

$$PWM = PWM + 2y \tag{2}$$

The implementation of the rule base of the diffuse controller was simulated and characterized initially on MATLAB, where for the real application, this rule base is embedded inside the Raspberry by programming based on pyfuzzy diffuse logic tool. The Figure 7 illustrates the final control surface obtained, where can be appreciated that it does not generate jumps in the same, offering a soft and gradual control system, for the final lighting intensity variation.

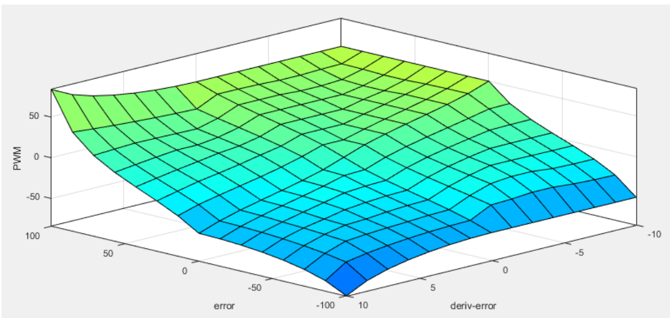

Figure 7. Surface view PWM change.

4 Results

Once established the communication via VPN from the control equipment to the domestic system based on raspberry, a connectivity test is performed, employing the ICMP protocol (Internet Control Message Protocol), using the PING command (Packet Internet Groper), which can be seen like a diagnostic tool in computer networks, which allows to check the communication state of the local host to the remote equipment and vice versa (Smartphone and the Raspberry). For that, on an IP network, by sending ICMP package of request (ICMP Echo Request) and reply (ICMP Echo Reply) is diagnosed the state, velocity and quality of the network evaluated. The Fig. 8 and 9 illustrate the response obtained by this way allowing to validate the connectivity and the response time, the Figure 8 allows to validate the local connectivity from the cell phone to the network that leads to internet, can be seen the two network jumps, from the wireless router and the output to the cloud.

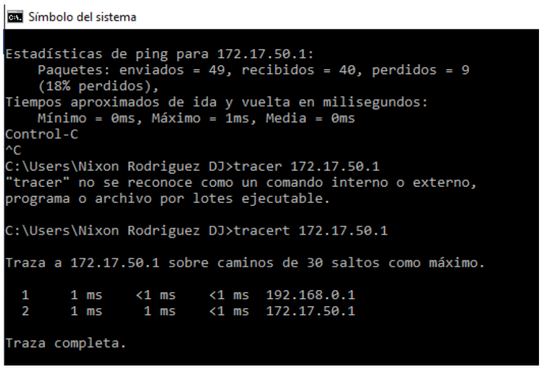

Figure 8. Local red response connectivity

On Figure 9 is validated the point to point connection and is observed the comparison with the access to a traditional search server, evidencing the advantage of using a VPN on access times, which for the case are reduced by a factor of between 5 and 6 times.

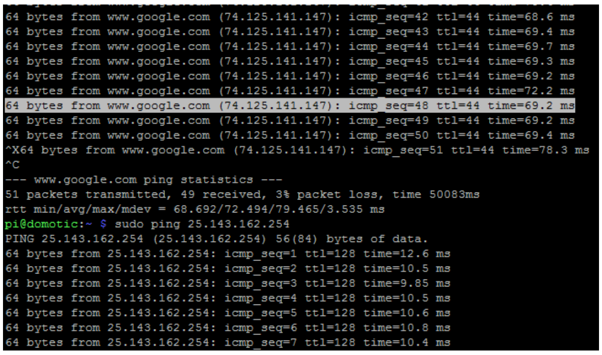

Figure 9. Response connectivity by internet.

The Figure 10 illustrates the connection points that represents the distance covered by internet, to achieve access to the intelligent bulb.

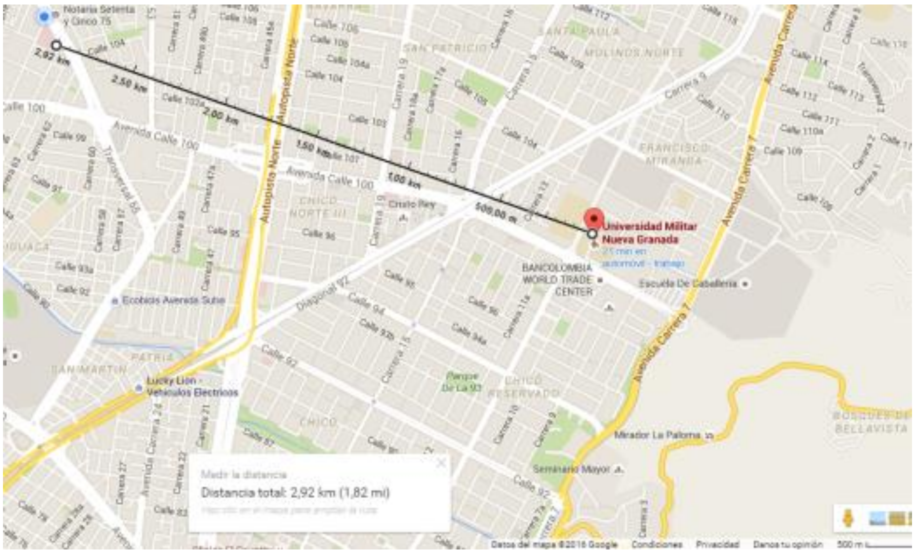

Figure 10. Distance from the set point.

5 Conclusions

It was possible to implement an intelligent bulb based on internet of things concept its activation can be given from any part of the world with internet connectivity and at the same time the location of the bulb is not tied to a particular site.

The access times to the IoT bulb are reduced compared to the access to a cloud-based search server, allowing a command action "almost instantaneous", in such a way that even in case of a wrong setting of the intensity level, can be corrected "instantly".

The diffuse control system allowed to give the "intelligent" aspect to the LED bulb, being able to maintain an average light intensity in relation to the one indicated by the user and opening the possibilities of its use to diverse systems like home automation, precision agriculture, cleanroom control, etc.

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