Intelligent Lighting Control

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THE PROJECT

Street lights on Smart Cities: contribute to energy savings

- Monitoring and control of each lighting installation
- Alert Notification hardware lighting
- Establishment of adequate light intensity at each public road
- Control of consumption
THE PROJECT II

Optimization of energy consumption in Smart Cities
Intelligent Lighting Control System
Gestión Inteligente y Visualización de Información

PROJECT OBJECTIVES
ARCHITECTURE
LIGHTING CALENDARS
CONSUMPTION TECHNOLOGIES
TESTS
CONCLUSIONS
Objetives

• Lighting management calendars.
• Adequacy luminosity based on traffic and pedestrian flow through proposed algorithms.
• Design method to limit consumption in lighting.
• Synchronizing lights on and off based on an astronomical clock, and weather prediction.
• Prediction and historical consumption.
• Web interface.
Architecture

- Union with OESC_CAD interface
- GUI to manage the functionality provided by the server OESC_GIVI
- Responsive interface, internationalized
- All business logic
- Daemon processes: meter reading, lighting weekly calendars
- Exposes functionality via REST Web Services

Framework Web
Django para Python

Servidor OESC_GIVI

REST

JDBC

Base de datos

PostgreSQL

Java EE

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Lighting Calendars

Manual setup: the user customizes the light patterns of each day

2 options

Smart Configuration: the system estimates the proper lighting schedule for each zone based on the use of public roads
Smart Configuration

1. **Classification of days** based on historical data of traffic and pedestrian flow.

   Analysis of variance (ANOVA)

2. **For each group of days, hours classification** depending on traffic and pedestrian flow.

   EM (Expectation-maximization) algorithm (EM)

3. **Adjust light intensity (lumens)** as a function of average pedestrian / traffic flow of each cluster.
Smart configuration with estimated maximum expenditure

- Adequacy of lighting schedule based on the use of public roads, but ensuring maximum estimated annual expenditure.
- Respects minimum limits of brightness to suit the laws of each place.
- Try adjusting spending introduced optimum brightness level in each hour.

Decreases luminosity in slots with a lot of luminosity
Respects minimum luminosity

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Smart configuration with estimated maximum expenditure

Distribution of expenditure

**STEP 1**
Extra expenditure = Total expenditure – minimum expenditure.

**STEP 2**
Extra expense distribution among groups of days.

**STEP 3**
Distribution expenditure of each type of days between slots with the same electricity rates.

**STEP 4**
Distribution of expenditure of each time slot for each hour of the night.
Hours on and off

The hours of “switch on and off” are different every day, depending on the hours of dawn and sunset, and the predicted weather.

Every week, for each facility:

1. Check the weather forecast (Yahoo Weather)
2. Setting times on and off depending on dawn and sunset hours and weather conditions
3. Sending lighting schedule for each facility (Web Service OCESC_CAD) and storing as historical data
Prediction and visualization of consumption

Consumption prediction
As we know the lighting calendars of each installation of street lighting, we will estimate the power consumed by luminaries.

Historical of consumption
Viewing historical data consumption.

Managing electricity rates
Term of active energy (kWh price)
With and without time restrictions
Predicting consumption: use of neural networks

Necessary to know the power consumed by a lamp according to the light intensity projected.

Using neural networks: Multilayer Perceptron (MLP)

**Historical consumption data luminaires** (accessible through OCESC_CAD)

**Training 2 neural networks**

**Storage networks trained in database** (serialization)

**Consumption prediction of a facility**
Historical of consumption

- Reading consumption of the facilities every hour for changes in the price of KWh (different slots of the electricity tariff).
- Storage of historical data and forecast for each hour in the database.
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Technologies

SERVER OCESC_GIVI
- Java EE 7
  - EJB Stateless
  - JPA, EclipseLink
- Servicios Web RESTful
  - JAX-RS, Jersey
- Servidor: Glassfish 4
- Base de datos: PostgreSQL
- Librerías:
  - OCESC_CAD
  - Weka
  - Yahoo Weather
  - Sunset Sunrise Lib, Mike Reedel

WEB APPLICATION
- Framework web Django para Python
- Bootstrap: HTML5, CSS3
- jQuery:
  - jqPlot
  - fullCalendar
- Librerías:
  - OCESC_CAD
  - OCESC_GIVI
  - Google Maps API
Tests

Throughout the development of the project, the functional components have been tested in prototype shown in the figure.
- Proper establishment of lighting calendars.
- Comparisons between expected and historical consumption.
Conclusions

- Management and development of lighting calendars:
  - Fusion of algorithms for finding light patterns depending on traffic and pedestrian flow.
  - Creating algorithm approximate maximum expenditure.
  - Real time control.

- Visualization and comparison of expected and historical consumption
- Flexibility in electricity tariffs.
- Integration of web interfaces.
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