

Adaptive Dimming Strategies for Urban LED Lighting: A MATLAB-Based simulation framework

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INTRODUCTION & AIM

Urban lighting has undergone a rapid shift towards LED technology due to its high energy efficiency, long service life and low maintenance costs. Despite this, most LED-based street lighting systems continue to operate at constant power levels throughout the night, regardless of actual traffic conditions or pedestrian activity.

As a solution, adaptive lighting systems further improve energy efficiency by dynamically adjusting the light output based on different times of day and pedestrian activity.

The aim of this study is to develop a MATLAB-based simulation framework capable of evaluating different adaptive dimming strategies for urban LED luminaires while maintaining acceptable visibility conditions on road surfaces.

METHOD

A simulation model was developed in MATLAB to evaluate the behavior of LED street lighting under different dimming control strategies.

The framework integrates:

- Photometric characteristics of LED luminaires
- Driver behavior under PWM dimming control
- Road surface illuminance calculations

Two adaptive regulation strategies were implemented:

1. **Scheduled dimming:** light output is reduced according to predefined hourly profiles during low-traffic periods.
2. **Traffic-responsive dimming:** luminaires adjust their output in response to simulated vehicle detection events.

The model allows comparison of the lighting performance and energy consumption for each control strategy.

The simulation environment is designed in a modular way, allowing different dimming strategies and control parameters to be easily modified and compared under various urban lighting scenarios.

RESULTS & DISCUSSION

The proposed simulation framework enables the analysis of adaptive dimming strategies for urban LED lighting systems. The modelling approach integrates photometric luminaire characteristics, PWM driver behavior and roadway illuminance calculations.

The conceptual diagrams presented illustrate the architecture of the adaptive lighting system, the simulation workflow, and an example of a time-based dimming profile used to define the operating scenarios.

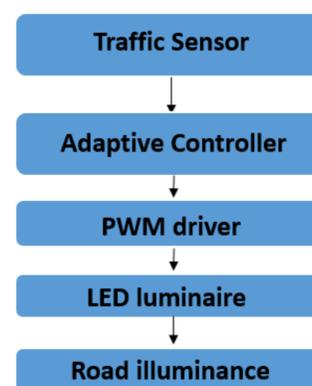


Fig 1. Adaptive LED lighting system architecture.

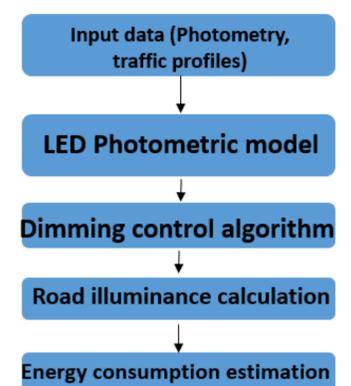


Fig 2. Simulation workflow

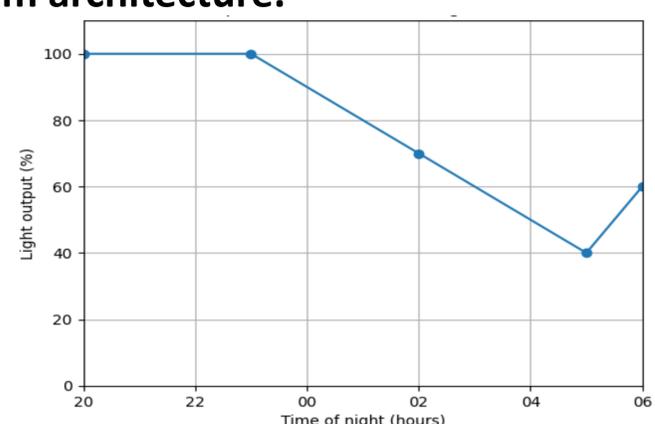


Fig 3. Example of a time-based dimming profile

CONCLUSION

This work presents a MATLAB-based framework to study adaptive dimming in urban LED lighting. It provides a simple way to explore more efficient and flexible lighting strategies under realistic conditions.

FUTURE WORK / REFERENCES

Future work will include real traffic data integration and the evaluation of additional adaptive dimming strategies.
CIE: Road Lighting Standards; IES: Lighting Handbook; Boyce: Lighting for Driving.