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Editorial

Special Issue "Smart Urban Lighting Systems"

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Abstract: The design and operation of multifunctional infrastructures for public lighting as well as their impact on the urban environment and citizens' life is today of great interest. The cost of energy for public lighting is often an issue for the budget of municipalities. Furthermore, researchers' and designers' attention is increasingly focused on aspects of public lighting not directly valuable through economic factors. Starting from the "quality" of the light environment, looking at citizens' visual comfort, the light has to be considered as an instrument to improve the urban context and objects therein (including buildings). Indeed, urban degradation (lack of infrastructures, maintenance, services, etc.) is linked to the poor quality of everyday issues, such as traffic, pollution, noise, lack of information, long times to access focal points, and the lack of safety. Simultaneously, in many areas, the potential related to the valorization of historical heritage is often underexploited. The installation of efficient lighting systems coupled with the implementation of ICT solutions can provide economic, social, and health benefits, energy efficiency, and visual comfort. On the other hand, as for indoor lighting, these systems can be expensive, not easy to maintain, and not as efficient as expected. The aim of this Special Issue was to investigate the problems and advantages of smart urban lighting systems in more detail. This Special Issue included 6 papers of the 10 submitted papers.

Keywords: urban lighting; smart cities; ICT in diffuse networks; energy efficiency; urban environment and technologies; smart energy infrastructures; building automation control systems

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1. Introduction

The six contributions of the present Special Issue are divided into three groups. The first one regards the papers that presented analysis and methodologies that can be useful to be applied during a design step. The second group provides two visions of an approach based on network architectures, communication technologies, and geographical databases for smart public lighting applications, showing their benefits and downsides also on the safety and social sides. The impacts, from two different points of view, of the applications of some of the abovementioned technologies is discussed by the two papers of the last group.

2. Methods and Approaches to Design

In general, to optimize a new urban lighting system, it is necessary to follow a specific methodology. It is even more important if the scale of the system design and the investment cost is large.

Tagliabue et al. [1] published a study for the planning of light renovations based on the correlation of Geographic Information System (GIS) data from different sources. The urban lighting data mapping could be an important tool to drive decisions on increasing the public lighting infrastructure since public light can improve social security and perception of physical degradation, increasing community pride and participation to the social and urban care. Authors correlated the quality of the street light in the different urban areas with other GIS data, e.g., the number and geographical distribution of road accidents in Milan were considered an example of metrics to be used to validate the proposed approach. The proposed GIS integration is a powerful tool for urban regeneration, driving urban policies at the local scale with an efficient granularity of intervention that could increase the quality of the urban environment.

As further work of this research, the idea is to extend the hard Key Performance Indicators (KPI) with the crowdsourcing data about perceived safety from the citizens (soft KPI), which can compose a structured proposal for implementing the lighting systems of the neighborhoods and provide the municipality with an effective strategic plan to develop the renovated university campus area.

In the research presented by Leccese et al. [2], an analysis of the correlations between spatial properties (expressed by spatial indicators, for example, the integration index and the choice index) and lighting levels (expressed by lighting parameters, for example, luminance and illuminance) upon roads of an urban context was presented. This analysis was applied to the case study of the medium-sized town of Pontedera (central Italy). From the obtained results, authors observed how the correlations between integration index and luminance values could be significant in the case of roads equipped with lighting systems able to satisfy the lighting requirements established by the regulations. The presence of the discussed correlations lays the foundation for a change in the lighting design approach on the urban scale, being able to set lighting requirements on the basis of space syntax results without the use of traditional methods of road classifications involving traffic volume estimations.

3. Network Architectures and Communication Technologies

Pasolini et al. [3] provided a thorough discussion on network architectures and communication technologies for smart public lighting applications, showing their benefits and downsides. Starting with significant activity on research, implementation, and in-field testing, authors also outline the steps required for the deployment of smart public lighting infrastructure, each discussed in accordance with the network topology considered. Furthermore, some additional services that a smart public lighting infrastructure could support and the benefits that would arise from integration with the upcoming 5G cellular network were introduced.

Regarding the technologies that can be applied, Carli et al. [4] focused their attention on a method to select the optimal set of energy efficiency retrofitting interventions on public street lighting systems. Their methodology, applied in the city of Bari, defines a plan of retrofitting interventions which exploit the initial budget available for the investment as well as financial or environmental benefits and savings resulting from the implementation of energy efficiency measures. This study advanced the existing literature on public street lighting by addressing a new topic, namely the multi-period approach for the development of the optimal plan of energy retrofitting interventions in urban street lighting. Furthermore, authors plan to provide the city authorities in charge of energy efficiency and green energy for public lighting systems with a straightforward tool for defining the optimal plan of interventions, focusing on the lighting system. Indeed, the researchers declared that the merit of the developed approach was its generalizability to different types of optimization criteria. Whilst in the current model they selected the total energy savings as the optimization criterion, an interesting development of the research can be to apply the retrofit decision-making model to optimize other indicators commonly used for assessing the energy performance of road lighting and compare the insights that the model provides in these different scenarios. Their results found that input data frequently suffer from estimation uncertainties, and sometimes even very small errors could make the "optimal" retrofit solution irrelevant from the financial and environmental convenience perspective, and that public lighting systems are complex systems where retrofitting interventions produce a variety of consequences, related to economic, energy, environment, and quality of life factors. Authors proposed as further research, the analysis of this issue by extending the analysis to a multi-objective problem.

4. Impacts and Evaluation of Lighting Systems

Gutierrez et al. [5] presented a paper about a tool developed to evaluate user experiences of urban digital interfaces. The authors proposed an evaluation method that used 14 guidelines to analyze questions pertaining to efficiency, assistance and instructions, content structure, resemblance to reality, feedback interface, visual design, cognitive processes, internationalization, and perceptive access. The tool can be further used to identify obstacles that, once identified, can then be tackled and resolved in the design phase. Addressing obstacles in the design phase serves to prevent the creation of inefficient interfaces that would lead to poor user experiences, or, likewise, the rejection of these interfaces by users. To verify the effectiveness of the proposed guidelines in a real-world environment a field study was conducted in which eight urban interfaces located in different cities and countries were observed. The study revealed the issues typically encountered by users that prevent them from having satisfactory or enjoyable experiences when using digital urban interfaces. The paper concluded by identifying and discussing areas of opportunity for further research and improvements to the proposed guidelines.

As an example of a design of an indoor system, but that can be a ring of an "urban chain" of buildings, the study proposed by Hajjaj et al. [6] examined how an intelligent lighting system affects energy consumption in an office space. They evaluated the traditional intelligent lighting system and how to improve the best use of the intelligent lighting system by each user. Indeed, as affirmed by the authors, the user in the large office is often not able to change the level of luminance. Moreover, the traditional lighting system is not able to specify which desk is occupied or not occupied by each worker. The proper use of lighting control can affect power consumption, and the worker sometimes forgets to change the occupancy status after leaving the office, which affects the energy. The aim of this last paper was to find the best model of the intelligent lighting system to save energy by using the technology of sensing devices for detecting the occupancy of the desk.

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