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Architectural Valorization: Lighting Design Solution for the Bell Tower of “San Pasquale a Chiaia” Church

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Abstract. Christian churches and their bell towers represent a big part of the historical architectural heritage in Italy, and they had a major role in the development of the urban and social fabric of the Italian cities. This study is focused on the design of a lighting renovation for the bell tower of “San Pasquale a Chiaia” (Napoli, south of Italy). The lighting refurbishment is designed with the aim of: (i) emphasizing the architecture of the bell tower façades and (ii) providing a figurative and emotional role to the whole building. Several lighting scenarios have been implemented in order to compare the different luminaire types and arrangements on the basis of the effectiveness in valorizing the architectural characteristics of the bell tower, as well as the energy performances of the different design solutions. Finally, the best case has been further implemented in order to take into account the different needs of the historical building as well as the enhancement of the surrounding urban spaces.

1. Introduction

The illumination of the churches, and, in general, of places of worship, is mainly related to managing the light to create an involving atmosphere for the people. Lighting helps to draw the audience in by removing the separation between the monument and the audience area. Different scenarios can be set with a proper approach, resulting in an intimate, upbeat, solemn, or neutral perception of the monument [1].

The topic of enhancing and valorizing the cultural heritage has witnessed a growing interest in contemporary culture. Over the decades, a proper lighting design has become one of the main components of every urban project, as a result of the technical improvements in the lighting sector, as energy consumption and quality of emitted light, but also due to cultural and social phenomena [2]. Along with an increasing concern with outdoor lighting [3], urban refurbishment programs are progressively aiming to the enhancement of the identity of the cultural and architectural heritage of the cities, by actually designing and improving the light on the exterior of monuments, sculptures, buildings and structures; consequently, cities have started to live more at nighttime. There are more people enjoying nightlife today, when compared with the early 90s, and lighting is one of the dominating forces for this particular shift: a well-lit path or a well-lit monument or landmark invites spectators to enjoy the city atmosphere, along with its cultural assets and their characteristics [4].



The design of external lighting for a monument is mainly focused on the enhancement of its historical-artistic characteristics and its perception in the urban scenario. In order to have a good visual impact, it is necessary to use the light with extreme precision selected elements, while avoiding luminous flux dispersion in other directions, also to avoid as much as possible the light pollution of the environment [5]. In Italy, many municipalities are undertaking the renovation of public lighting system, by substituting the existing luminaires with new ones equipped with Light Emitting Diode (LED) technologies, to increase the energy efficiency, reduce the maintenance costs, while improving the lighting performance [6]. Moreover, LED luminaires are often characterized by specific designed optics, highly effective in focusing the luminous flux on the selected areas; consequently, the light pollution and unnecessary energy consumption can be reduced. However, in the past, the luminaires replacement often involved the replacement of warm white light sources (2500 K) with a low Color Rendering Index (CRI), typical of high-pressure sodium systems, with colder white light sources (about 4000 K) with a higher CRI [7]. These refurbishment actions raise questions on the use of such high Correlated Color Temperature (CCT) light sources, in particular on the effect on the typical perception of architectures and urban landscapes. In order to overcome these criticalities, today it is possible to use LED sources with lower CCT, which are able to better simulate the perceptive effect of typical high-pressure sodium systems, while still improving color rendering and energy efficiency. In general, from the analysis of the current situation, it emerges that, in most cases, there still is a general lack of proper guidelines for the lighting design of monumental buildings, a fundamental step in the improvement of the perception and valorization quality of the cultural heritage and the touristic attractiveness of the sites [7].

In this work, the case study of the lighting refurbishment design for the bell tower and the main façade of the Church of “San Pasquale a Chiaia” is discussed: four different scenarios have been carried out in order to compare the different luminaire types and arrangements on the basis of the effectiveness in valorizing the architectural characteristics of the bell tower, as well as the energy performances of the different design solutions. Finally, the best case has been further investigated in order to maximize the enhancement of the characteristics of the monument as well as its perception in the urban scenario.

2. The Church of “San Pasquale a Chiaia”

This research is focused on the bell tower of Church “San Pasquale a Chiaia” and its main façade, one of the monumental buildings of Naples (south of Italy). The district of Chiaia began to conform in the sixteenth century outside the city walls thanks to the construction of summer residences by aristocratic families, but in the second half of the nineteenth century, the appearance of the district began to change due to the advancement of the coastline [8]. The Church is a beautiful example of Baroque art in the city, founded, along with the convent, in 1749 on a pre-existent monumental palace owned by Francesco di Laurina y Ulloa, Duke of Lauria [9], by the will of the Alcantarini friars of San Pasquale, from Lecce. The design draft was made by the Indian architect A. di Borbone, while the construction site was directed by the royal architect G. Pollio [10]. The Church has a Greek cross plan, with a side-oriented entrance: initially, it had the same extension as the annexed cloister, both converging in the piperno stair, a remain of the former monumental palace. During the years, the number of friars had risen, so several modifications were made to both the convent and the Church, in particular with the addition of an additional span [11]; in order to accommodate the extensions, the surrounding area was bought too from the Duke of Maddaloni, reserving part of the area as a public space [10]. Between the 1820 and 1826, the floor, originally made from varnished terracotta tiles, was made in marble tiles, by design of the architect Barletta and the artisan R. Trinchese. During 1838-1839 the second floor of the convent was built, an alteration which then required a significant structural restoration [10].

The monumental complex of San Pasquale a Chiaia was designed as a typical Baroque complex; however, during the centuries, several characteristics from the Neo-classicism style influenced the intervention on both the Church and the convent [11].

Figure 1 reports the view of the main façade of the Church and its bell tower. In particular, Figure 1a shows the current status of the Church during the daytime, while Figure 1b shows the current status of the Church during the nighttime. The façade is divided vertically by two pairs of pilasters; at the center, it has a simple portal surmounted by a large window. The façade is crowned with a broken tympanum and a large stucco high relief depicting San Pasquale. On the right, it stands the bell tower, divided into four levels, through which it is possible to access the cloister (where there is a reproduction of the Grotto of Lourdes) and the convent. The interior has a single nave with side chapels, while along the entire upper perimeter, there is a matroneum separated by wooden grates. The Church holds several paintings, displaced along with the altars [11].

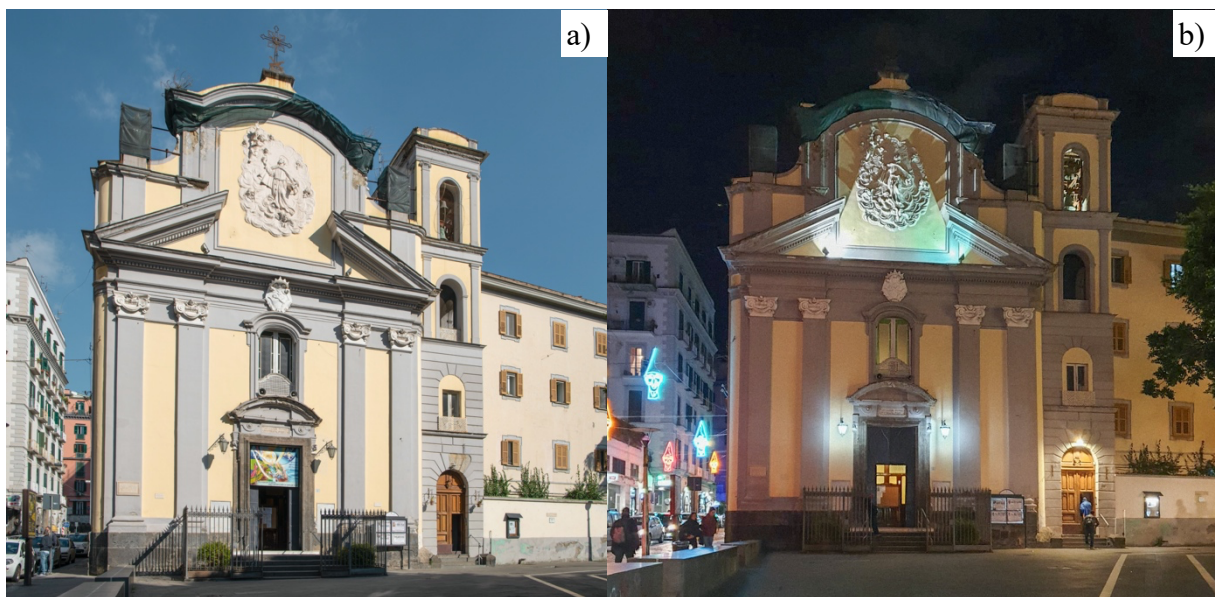


Figure 1. Façade of Church of “San Pasquale a Chiaia” during a) daytime and b) nighttime.

3. The state of art

In the first step of the research, a geometrical and photometric survey of the San Pasquale a Chiaia Church as well as its square was carried out. As highlighted in Figure 1b, the current artificial lightning system illuminates the: (i) large stucco high relief depicting San Pasquale, (ii) the entrance of the Church, (iii) the entrance at the base of the bell tower to the cloister and (iv) the belfry interior. Figure 2 reports a view of the currently installed luminaires. In particular, Figure 2a shows one of the two projectors installed on the Church façade to illuminate the large stucco high relief depicting San Pasquale; Figures 2b and 2c highlight the two lanterns and the spotlight installed to light the entrance of the Church and the entrance to the cloister at the base of the bell tower, respectively. Figures 2d and 2e show one of the nine square lamps and the street lamp used to illuminate the San Pasquale square, respectively. As highlighted in Figure 2e on the top of the street lamp pole, two projectors have been installed to illuminate the whole Church area. All the luminaires installed have different color temperatures (see Figure 1b); in particular, the Church façade is strongly illuminated with cold light sources, while the bell tower is poorly illuminated with warmer light sources. This light inhomogeneity produces a general lack of depth on the façades and it does not allow a correct perception of all their elements.

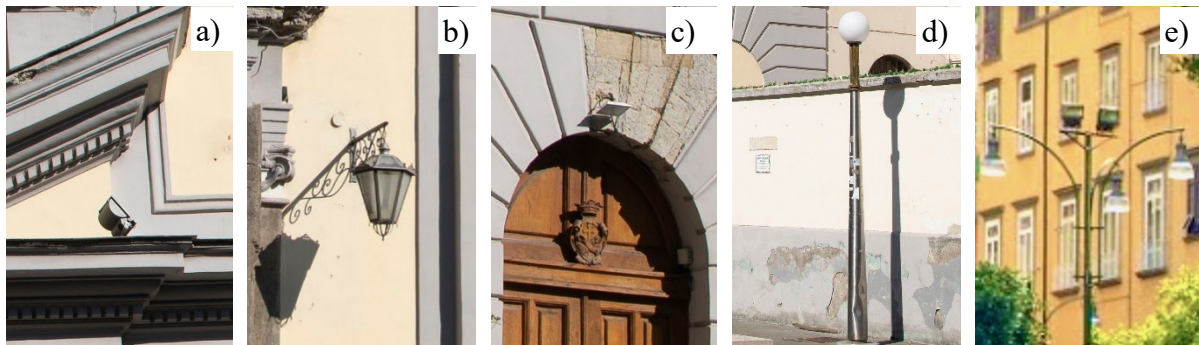


Figure 2. Current lighting luminaires that illuminate a) the large stucco high relief; b) the entrance of the Church; c) entrance at the base of the bell tower to the cloister; d) one of the nine square lamps; e) street lamp.

In order to evaluate the current lighting conditions, the illuminance values on the church façade and in the square were acquired thorough spot measurements using the illuminance meter Konica Minolta CL200 [12]. Both vertical and horizontal illuminance values were acquired at the height of 1.80m. For each measurement point, a set of five acquisitions were performed. Figure 3 reports the layout of the San Pasquale square, highlighting the measurement points and the luminaires’ positions. In particular, the horizontal measurement points are highlighted in red, while the vertical ones are highlighted in blue. Table 1 reports the average illuminance values for each measurement point.

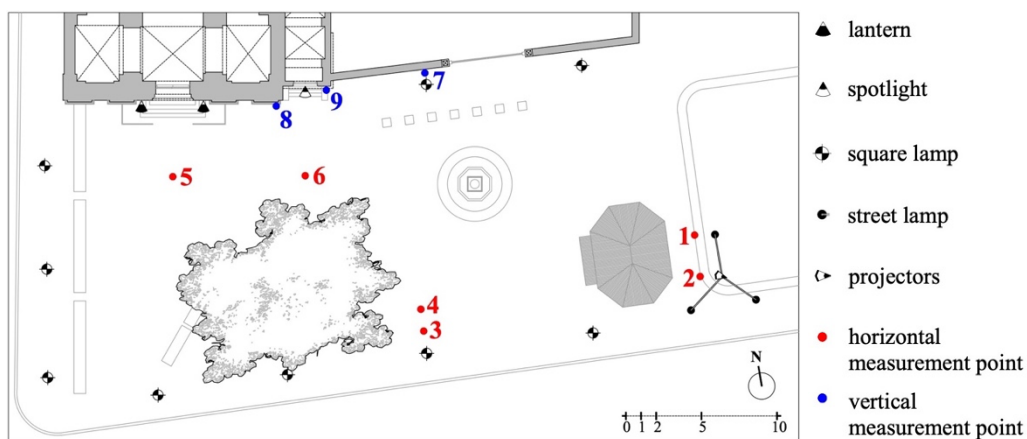


Figure 3. Layout of the luminaires and acquisition points.

Table 1. Mean values of illuminance for each measurement point.

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9
Mean Value (lx)	102.6	68.1	144.4	77.5	3.7	8.8	122.6	12.1	19.1

The measured illuminance values return a scenario in which neither the square, nor the church façade or the bell tower, are well lit, thus requiring a lighting refurbishment design to properly valorize the monument and the surrounding area.

Finally, the photometrical characterization of the external surfaces of the Church and the bell tower was performed by using a spectrophotometer Konica Minolta CM-2600d [13], with the standard illuminant D65. The measured reflection coefficient and the colors values, expressed in RGB values (0 – 255), are listed in Table 2. These values were used to develop the virtual 3D-model of the Church, the bell tower and the square in DIALux Evo software [14].

Table 2. External surface materials.

Material	Stone basement	Gray plaster	Yellow plaster	Marble
Reflection coefficient	10%	41%	73%	70%
Color RGB	128, 118, 105	177, 170, 164	247, 218, 176	237, 229, 225

4. Refurbishment methodology

In order to define the best design solution, a virtual model of the Church façade, the bell tower as well as the square was realized in the simulation software DIALux Evo. The use of this software allowed to compare and optimize various design solutions. Four different lighting scenarios were developed and then compared, from an architectural and energy point of view, with the aim of identifying the optimal lighting configuration, the source types and their correct positions.

Table 3 reports the LED luminaires, by iGuzzini [15], with the manufacturer's code, the luminous flux, the electric power and the number of luminaires used for each scenario. As suggested by [16,17], all luminaires have a CCT of 3000 K and a CRI of 80.

Table 3. Luminaires used in the virtual scenarios.

Manufacture model	Luminous flux for a single luminaire (lm)	Electric power consumption for a single luminaire (W)	Number of luminaires for each scenario			
			Scen. #1	Scen. #2	Scen. #3	Scen. #4
BG97 Linealuce Compact 75	504	8.3	1	1	1	1
BH09 Linealuce Compact 75	725	9.0	4	3	6	-
BK05 iPro - 51mm	108	1.4	1	1	1	1
BK32_iPro - 81mm	829	13.0	2	-	-	-
	494	7.7	-	2	2	2
	976	3.8	-	-	4	4
BJ89_iPro - 51mm	41	4.6	-	-	4	4
			-	-	8	-
BJ99_iPro - 51mm	348	4.2	-	-	4	6
	177	2.2	-	-	-	2
	147	1.8	-	-	-	2
BY76 1278 X102 Twilight	2290	20.1	9	9	9	9
	1160	12.0	2	-	-	-
BV16 iTeka 23,8W	2280	23.5	-	-	-	1
	1800	18.6	-	-	-	1
	300	8.6	-	71	12	14
E443_Underscore InOut	1200	34.3	-	2	2	-
	700	20.0	-	-	-	2
	200	5.7	-	-	-	2
	100	2.9	-	-	-	2
E889_Twilight	850	10.8	2	2	2	-
	500	6.3	-	-	-	2
E885 Laser Blade InOut	687	12.5	8	-	-	8
BC20 iRoll 65	898	11.4	4	-	-	-
BK81 Linealuce Mini 37R	960	12.6	-	2	-	-
BB56 B987 Ledplus	568	16.2	-	4	-	-
7336 MIN Woody - ø140mm	233	77.7	-	-	-	4
P791 Platea Pro	2469	35.3	-	2	-	-
BK25 iPro - 81mm	494	7.7	4	-	-	-
Q695_Palco iNOut - ø49mm	363	5.9	-	2	-	-
	181	2.9	-	-	2	-

The study starts from the lighting design of the bell tower, characterized by four levels: the first two levels present a simple decoration with horizontal ashlar in grey plaster, while the last two levels present

a yellow plaster with two grey pilasters on each façade and a grey stucco frame in relief around the openings. The openings at the first two levels are also windowed, while those at the last two levels are entirely opened without any fixture; in the last two levels, a metallic fence has been installed in correspondence of each opening. The four levels of the bell tower present four different heights each: from the ground up i) 6.5 m, ii) 4.3 m, iii) 3.7 m, and iv) 4.9 m.

The strategies suggested in [16,17] were implemented in the refurbishment scenarios. Three different strategies (vertical, horizontal, and mixed) were implemented in the first three scenarios, enhancing the historical-artistic characteristics (the bell tower, the belfry, the geometries, and ornamental stuccos on the Church façade) of the monument. Finally, a fourth optimized strategy has been used in the last scenario, in order to implement the best solutions from the previous ones.

5. Refurbishment scenarios: results and discussions

In this section, the modeled scenarios are analyzed and discussed, on the basis of the images elaborated by the DIALux Evo software. Table 4 reports the elaborated images for the three first scenarios, from two different points of view.

Table 4. Images elaborated for the first three scenarios.

	View 1	View 2
Scenario #1		
Scenario #2		
Scenario #3		

In Scenario #1, floodlights with different luminous fluxes were implemented, with the aim to level out the different heights of the four bell tower levels. This kind of lighting enhances the verticality of the building and highlights the openings and decorations on the façades. The bell tower was also illuminated from the inside in the last two levels, emphasizing the belfry. The Church, on the other hand, was illuminated with the aim of highlighting the main features of the façade, such as the central high-relief and the decorations at the top. In addition, the four pillars were lighted with up-and-down lamps, which break the height of the pillars at the same height of the bell tower first level and the church portal, highlighting the capitals. The first scenario involves the installation of 37 lamps with a total electric nominal power of about 474 W and a total luminous flux equal to 40.86 klm.

Instead, Scenario #2 has been developed considering a horizontal lighting strategy. In order to enhance the different heights of the four levels of the bell tower, the lamps were installed on the top and bottom of the cornices, effectively separating each level. In addition, following the same lighting approach: (i) a set of luminaires on the ground to create a uniform lighting condition on the Church façade, (ii) lamps on the top and bottom of the broken tympanum cornices, and (iii) lamps on the top and bottom of the cornices located on the top of the building to highlight the summit ornaments, were installed. This kind of design strongly highlights the horizontal elements of the buildings, i.e. highlighting the geometries of the broken tympanum. The second scenario involves installing 101 lamps with a total electric nominal power of about 1104 W and a total luminous flux equal to 59.64 klm.

In Scenario #3 the bell tower was illuminated, highlighting the ashlar with spot luminaires at the first two levels, as well as the pillars with super-spotlight lamps at third and fourth levels. Additional external lamps at the center of the openings and mini-spotlight inside the belfry were used, in order to provide more emphasis to the bell tower façade rhythm. The same approach has been used for the Church: the pillars were illuminated with super-spotlight lamps, the spherical ornaments at the top of the façade are accented with dedicated lamps, the broken tympanum was emphasized along its cornices, while the high-relief was lighted by spotlights from the tympanum. In the third scenario, 57 lamps are installed with a total electric nominal power of about 545 W and a total luminous flux equal to 37.48 klm.

Afterwards, a fourth optimized strategy has been used in Scenario #4. This scenario was designed using the best solutions resulting from the previous approaches. The bell tower lighting configuration from Scenario #1 was re-proposed in this scenario. This solution follows the fundamental principles of a correct illumination for slender buildings, to emphasize the shapes and highlight the details of the ornaments. The luminaires installed on each cornice emphasize the heights of bell tower levels, while producing at the same time a horizontal effect by illuminating the cornices from below. In the same way, the Church was lighted following the same principles: the pillars of the Church were highlighted from the bottom using spotlights with a narrow luminous flux and the capitals were emphasized by small projectors placed on the ground, one for each pillar. In order to enhance the form of the broken tympanum, LED strips were installed on the cornice: the lights pointing downwards emit a luminous flux constant along the whole length, while those pointing upwards fade from the center to the angle of the tympanum. In addition, two spotlights were installed at the external vertices of the tympanum, in order to further define its geometry. A total of four small spotlights have been added on the tympanum cornices to illuminate the stucco of San Pasquale. Finally, the ornaments at the summit of the façade have been highlighted with dedicated strip lights. Figure 4 reports the elaborated images for the last scenario: two global (Figures 4a and 4b) and two detailed views (Figures 4c and 4d). The fourth scenario involves installing 67 lamps with a total electric nominal power of about 975 W and a total luminous flux equal to 44.43 klm.



Figure 4. Scenario #4: a) front and b) side views, details of c) the top and d) the bottom of the façades.

Finally, to calculate the yearly electric energy consumption for the different scenarios, an operation schedule has been hypothesized: the luminaires were set to turn on at sunset, along with the public lighting system, then turn off at midnight, during the weekdays, or at 2:00 AM, during the weekends, for a total of 2239 hours. In Table 5, the characteristics of the design solutions and the yearly electric consumption for the different scenarios are reported.

Table 5. Summary of the performances upon varying the scenario.

	Scenario #1	Scenario #2	Scenario #3	Scenario #4
Total luminous flux (klm)	40.86	59.64	37.48	44.43
Total electrical power (W)	474	1104	545	975
Number of luminaires	37	101	57	67
Yearly electric energy consumption (kWh/year)	1061	2471	1221	2183

From the table, it is possible deduce that:

- Scenario #1 shows the best results in terms of energy consumption; however, in this scenario, the least number of lamps is installed, therefore resulting in a non-optimal illumination of the whole monument;
- Scenario #2 presents the higher number of installed lamps, resulting in the more expensive scenario in terms of both number of lamps to be purchased and electric energy consumption;
- Scenario #3 shows the less ideal results with respect to the other refurbishment scenarios, presenting the lower total luminous flux despite having an intermediate number of installed luminaires and an average electric energy consumption;
- Scenario #4 seems to be the best compromise in terms of luminous flux on the whole monument, number of installed lamps, as well as electric energy consumption.

6. Conclusions

In this research, the case study of the lighting refurbishment design for the bell tower and the main façade of the Church of “San Pasquale a Chiaia” is discussed: four different scenarios have been carried out in order to compare the different luminaire types and arrangements on the basis of the effectiveness in valorizing the architectural characteristics of the bell tower, as well as the energy performances of the different design solutions. In order to define the best design solution, a virtual model of the Church façade, the bell tower as well as the square was realized in the simulation software DIALux Evo. The lighting scenarios were developed and then compared, from an architectural and energy point of view, with the aim of identifying the optimal luminaires configuration, the source types and their correct position. In the first three scenarios, three different strategies (vertical, horizontal, and mixed) were implemented, enhancing the historical-artistic characteristics (the bell tower, the belfry, the geometries and ornamental stuccos on the Church façade) of the monument. In Scenario #1, floodlights with different luminous fluxes were implemented with the aim to enhance the verticality of the building. Scenario #2 has been developed considering a horizontal lighting strategy, effectively separating each level of the bell tower and Church façade. In Scenario #3, the mixed strategy resulted in a flood-lit effect, thus flattening the three-dimensionality of the monument. Finally, a fourth optimized strategy has been used in Scenario #4. This last scenario was conceived using the best solutions resulting from the previous approaches, enhancing both the historical-artistic characteristics and the perception of the monument in the urban scenario; moreover, Scenario #4 resulted as the best compromise in terms of luminous flux on the façades, number of installed lamps, as well as electric energy consumption.

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References

- [1] B. Herring, “Herring Lighting and Video: A Resource for Worship”, Chapter 16 - Beyond Illumination — Using Lighting for Design, editor: Focal Press, Boston, pp. 157–76, 2009.
- [2] K.P. Mansfield, “Architectural lighting design: A research review over 50 years.” *Light. Res. Technol.*, vol. 50, pp. 80–97, 2018.
- [3] W. Jankowski, “Lighting: Exteriors and Landscapes”, editor: PBC International Inc., New York, 1993.
- [4] M. Tural, C. Yener, “Lighting monuments: Reflections on outdoor lighting and environmental appraisal.”, *Build. Environ.*, vol. 41, pp. 775–782, 2006.
- [5] F. Falchi, R. Furgoni, T.A. Gallaway, N.A. Rybnikova, B.A. Portnov, K. Baugh, P. Cinzano, C.D. Elvidge, “Light pollution in USA and Europe: The good, the bad and the ugly.”, *J. Environ. Manage.*, vol. 248, 2019.
- [6] M. Beccali, M. Bonomolo, A. Galatioto, E. Pulvirenti, “Smart lighting in a historic context: a case study.”, *Manag. Environ. Qual. An Int. J.*, vol. 28, pp. 282–298, 2017.
- [7] L. Valetti, A. Pellegrino, C. Aghemo, “Cultural landscape: Towards the design of a nocturnal lightscape.”, *J. Cult. Herit.*, vol. 42, pp. 181–190, 2020.
- [8] I. Ferraro, “Napoli Atlante della Città Storica – Chiaia”, editor: Oikos Edizioni, Napoli, 2012.
- [9] G.G. dell’Addolorata, “S. Pasquale a Chiaja in Napoli”, editor: Grimaldi & C. Editori, Napoli, 2005.
- [10] S. Cassani, D. Campanelli, F. Chiurazzi, “Napoli città d’arte”, San Pasquale a Chiaia, editor: Electa Napoli, Napoli, 1986.
- [11] V. Regina, “Le chiese di Napoli”, editor: Newton Compton Editori, Roma, 2015.
- [12] Konica Minolta Sensing Europe B.V., “Incident Color Meter CL-200”, accessed on Apr 14, 2021.
- [13] Konica Minolta Sensing Europe B.V., “Portable Spectrophotometers CM-2600d”, accessed on Apr 14, 2021.
- [14] DIAL GmbH, “DIALux Evo”, accessed on Apr 14, 2021.
- [15] iGuzzini illuminazione S.p.A, “Outdoor Lighting”, accessed on Apr 14, 2021.
- [16] M. Scorpio, R. Laffi, M. Masullo, G. Ciampi, A. Rosato, L. Maffei, S. Sibilio, “Virtual reality for smart urban lighting design: Review, applications and opportunities.” *Energies*, vol 13, 2020.
- [17] R. Laffi, S. Sibilio, M. Scorpio, G. Ciampi, A. Rosato, Y. Spanodimitriou, “The lighting refurbishment of places of worship: The case study of the Church of “Santa Maria di Piedigrotta.”” *Proc. Sci. Technol.*, vol. 2, pp. 102-112, 2019.