Dynamic and Interactive Lighting for Fashion Store Windows

Paolo Cremonesi
Antonella Di Rienzo
Franca Garzotto
Luigi Oliveto
Pietro Piazzolla
Department of Electronics,
Information and Bioengineering,
Politecnico di Milano
Via Ponzio 34, Milan
[name.surname]@polimi.it

CHI'16 Extended Abstracts, May 07-12, 2016, San Jose, CA, USA
ACM 978-1-4503-4082-3/16/05.
http://dx.doi.org/10.1145/2851581.2892461

Abstract
Smart light technology offers new dynamic and interactive capabilities that extend the potential of traditional lighting systems of attracting people and affecting their mood, emotions, and behavior. Our research explores smart lights in the context of shopping windows. The paper describes an extensive empirical study that has been performed for 5 weeks in a fashion store located a top-level shopping area in Milan (Italy). The data automatically collected from over *1 million people* passing by or stopping in front of the 3 shopping windows of the store in three different lighting conditions (static, dynamic, and interactive) enable us to provide some empirical evidence of the potential of smart light technology to enhance the shopping experience in brick-and-mortar stores.

Author Keywords
Interactive light; Shopping Windows; Fashion; Retail

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction
With the increasing competition from online shops, retailers are looking for new ways to attract customers to physical shops and enhance the shopping experience in brick-and-mortar stores. To this end, shop windows

are an essential ingredient, to grab passers-by attention, communicate a store's products and brand, differentiate a store from the others in the same street, and trigger the impulse of entering it.
Lighting can play a strong role in a shopping window and contribute to achieve the above goals. Prior research about store's atmospherics ([7][2][13]) pinpoints that light creates visual and emotional effects that improve the aesthetics of a shopping window, emphasize or de-emphasize the exposed items, affect the look of mannequins, and positively influence persons' mood and behavior [5]. For example, Areni and Kim [1] establish a link between the brightness of lighting and increased examination of merchandise. (Quartier et al. [12]) discuss how lighting can build an attractive atmosphere in retail environment that can positively influence customers' behavior, while (Schielke [14] [15]) highlight the effects on brand image.
With the latest innovations in the field and the blending of lighting and digital technology, lights have become "smart" and offer new dynamic and interactive capabilities, e.g., changing color and intensity in response to direct user actions (such as control via remote tablet/smart phone [6], voice, hand and body movements) and to environmental parameters such as time of the day, power consumption [3], and temperature, and similar.
Several studies have been focusing in behavior change interventions using engagement-oriented solutions, for instance Piano Stairs (a.k.a. Piano Staircase) was implemented at the Stockholm subway station in order to get more people to take the stairs over the escalator[16].
Similarly, smart lights, compared to traditional lighting systems, enable the creation of more engaging effects (e.g. the so called honey-pot effect [8]) in shopping windows that, in principle, have an enormous potential to address the needs of retailers in physical shops and therefore improve their business. Because of their dynamic and aesthetic quality, smart lights may attract more passers-by towards the window; they may increase the time spent in front of the windows, by offering an interactive experience; they may draw attention to different displayed items highlighted in a dynamic sequence; finally, smart lights may differentiate and improve a shop brand image with a touch of "high-tech" and, overall, lead to a higher number of people entering the physical store. In addition, the inclusion of presence sensors in a smart lighting framework enables the automatic collection of quantitative information that can help retailers measure the effectiveness of their shop windows.
In spite of these arguments, there is limited empirical evidence of the potential of smart lights (Pihlajaniemi [11]). This paper provides a contribution in this arena. We describe a wide field study that has been performed in a real fashion shop in Milan, Italy, for a period of 5 weeks. The goal of the study is to explore the impact of smart lights in shopping windows, in terms of how much these lights can increase the attractiveness of the store. To this end, we got quantitative and qualitative proof points on the value that retailers can gain from dynamic, interactive lighting and customers' automatic data collection.

As discussed in the following sections, we have automatically collected data from over 1,000 people passing by or stopping in front of the 3 shopping windows of the store in three different lighting conditions (static, dynamic, and interactive). Data about users presence, movement or gestures were

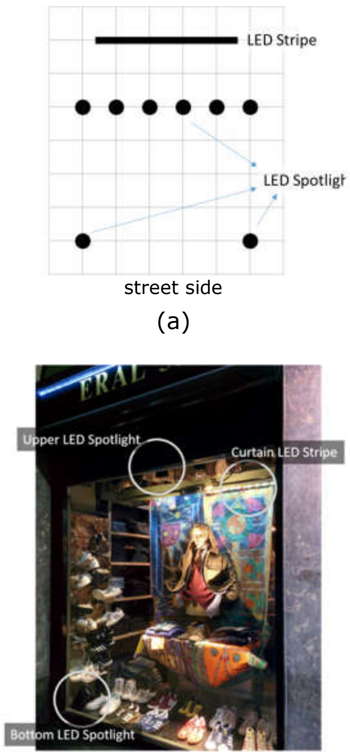

Figure 2: Lighting setting schema of each shopping window

collected using Microsoft Kinect motion sensor only. In this way no sensible information were recorded about given individuals, thus not raising any privacy issue according to the Italian laws.

The study

Context
A smart light system has been installed in 3 shopping windows of a high end men clothing store in one of the trendiest, most crowed and well-lit shopping areas in Milan (in Figure 1).

Figure 1 - The shop in Milan

Lighting System
The system consists of 8 Philips Color Kinetics compact burst spot lights and 4 Philips Color Kinetics Fuse Powercores used as graze lights for the curtain. The light configuration is schematized in Figure 2. The lighting was managed using a light playback controller produced by Pharos [9] and related software [10].

We defined three different lighting scenarios: static, dynamic and interactive. When a light scenario was active during a day, it was used by all the shopping windows.

The static scenario was used as a baseline to measure the effects of smart lights. It was a light setting where the single LED spotlights and stripes have fixed color and intensity.

The dynamic scenario provides dynamic lights that automatically change in terms of light intensity and speed, according to an iterative pattern, as shown in Figure 3. Please see Figure 4 for the legend.

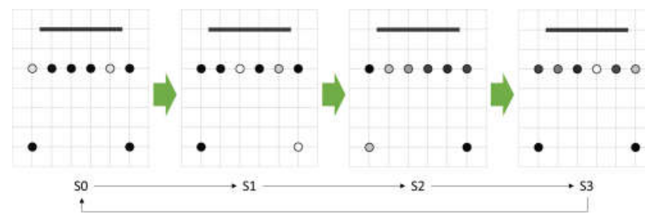

Figure 3 – Dynamic light progression

The interactive scenario adds some interaction capability to the dynamic scenario. The lighting system is integrated with a user detection module that can recognize user's proximity and movements (e.g., the pointing gesture of the closest user) using a Kinect sensor and transforms these data into specific commands for the light control components. Lights change is based on the same topological patterns as the dynamic scenario, but light intensity and speed of light activation/deactivation in each pattern depend on the presence of the users in front of the shop window, as well as the sequence of patterns. When no users are in front of the shop window, the lights change

Figure 4: The legend for light setting schemas.

automatically as the dynamic scenario, but at a high speed. When some users approach the window, the lights slow down. When the closest user points with the hand to a specific window area, there is an enlightenment of that zone. The user can point to the left, to the center and to the right, achieving the lights effects outlined in **Figure 5**.

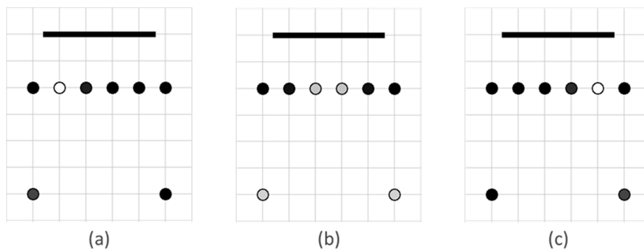

Figure 5 – Interaction effects: a) pointing left, b) pointing center, c) pointing right.

Finally, the system includes a log module, which tracks different information about passing people like the date and time when the user enters and exits the recognition area. Tracking of passing people is performed by using the Kinect active infrared sensors, one for each shopping window. These sensors offer number of advantages over more conventional technologies, such as video cameras and passive infrared sensors. Animals or other objects (e.g. bikes) are not captured by the Kinect sensor. Moreover, the sensor range can be easily adjusted and tuned to account for different layouts of the sidewalk in front of the shopping window. Finally, there are no privacy issues compared to camera sensors.

Results

In this section, we present some results obtained during the still ongoing analysis of the collected data. In particular, we focus this early investigation on how the different light and interaction settings influenced the attractiveness of the shopping window, measured in terms of time spent looking at the shopping window.

The experiment has been run for 33 consecutive days (almost 5 weeks), and the Kinect sensors tracked **over 1 million of passers-by** (people passing-by or stopping in front of the sopping windows). The first 12 days of the experiment have been used to tune the Kinect sensors (position, orientation, sensitivity) and have not been included in the analysis. The remaining 21 days (**3 weeks**) have been used for the analysis, one week for each experimental condition (static lights, dynamic lights, interactive lights). Because the shop has different opening hours depending on the day of the week, we considered only people tracked between 11:00 and 19:00 (**8 hours interval**), as the shop was always open during this time interval, regardless of the specific weekday. During the 3 weeks and 8 hours period, we tracked **471,091 passers-by**. In particular, 140,071 were tracked in days with *static* lighting, 133,090 in days with *dynamic* lighting and 197,933 in days with *interactive* lighting.

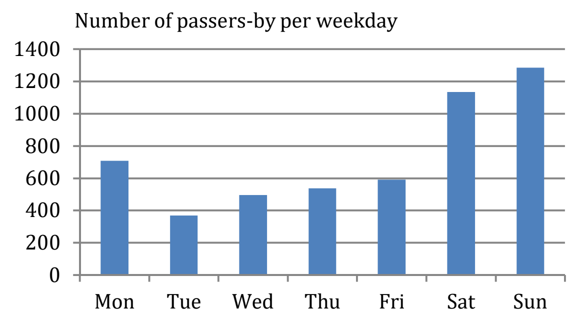

Figure 6 – Average number of tracked passers-by per weekday

Figures 6 and 7 show the overall distribution of the collected data. Figure 6 shows the average number of passers-by per weekday. As expected, weekends (Saturdays and Sundays) show larger numbers of people compared to working days. Figure 7 shows the distribution people on an hourly basis. It can be seen that foot traffic after 16.00 is 50% larger than during the morning hours.

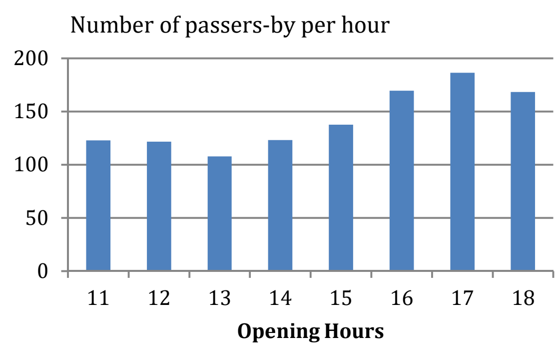

Figure 7 - Average number of passers-by per hour

For each tracked person we recorded the time spent in the range of the Kinect sensor along with the date and hour of the tracking. If a person stayed within the range of the Kinect sensor for more than 10 seconds, we assume that person is watching the shopping window (*stopped person*). The value of 10 second has been chosen to distinguish between people giving an occasional glance and people looking with interest [4]. A total of **9,571** people stopped in front of the shopping windows during the analysis period (3 weeks – 8 hours per day) and they account for 2% of the passers-by detected by the Kinect sensors over the same period. A one-way ANOVA test using **stopping times** as the dependent variable and the three light types as the independent ones suggests that a difference exists among the three lights conditions (*F(2, 19459) = 9.233, p = .00009*).

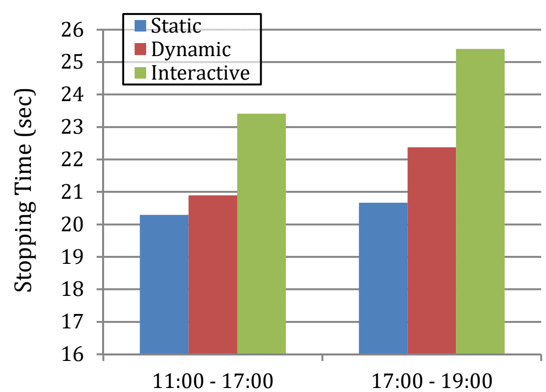

Figure 8 – Average time (seconds) spent in front of the shopping window, during different hours.

Figure 8 shows the average time spent in front of the shopping window for the three different settings (static lights, dynamic lights and interactive lights). Means are computed over stopped people only (i.e., passers-by staying more than 10 seconds within the range of the Kinect sensor). In order to investigate if the natural daylight has an impact on how passers-by perceive the lighting effects, results are further split into two experimental conditions, according to the hour of the day: 11:00–17:00 (daylight hours) and 17:00–19:00 (dark hours).

Figure 8 shows that time spent in front of the shopping window when static lights are on is almost identical between daylight and dark hours (20 seconds). Dynamic lights have almost no effect during daylight hours, while the stopping time is increased by 10% during dark hours. On the contrary, interactive lights are able to increase the stopping time during both daylight hours (+15%) and dark hours (+22%).

This preliminary suggests that interactive lights are effective in engaging passers-by to stay longer in front of the shopping window. This effect is stronger during dark hours, as expected, when lights are more visible. Dynamic-only lights, on the contrary, have almost no effect in engaging people.

Conclusions and future work

The results of our study are still preliminary and further analysis is needed to validate and extend our outcomes. We will also consider the qualitative information collected from 85 interviews to passers-by, which we haven't analyzed yet, and compare them with the automatically gathered data. The work performed so far pinpoints that the introduction of dynamic and interactive lights in shopping windows have some positive effects on the experience of potential customers, compared to the baseline condition of conventional lights (static scenario). Still, the impact of interactive lights is less strong than we may have originally expected. The limited effects of this scenario may be ascribed to the fact that we did not provide any explicit indication about the interactive capability of the light setting lights and people simply did not realize that they could interact with lights using body movement and gestures. This result, although limitative, support the argument that, at least so far, full-body interaction is much less natural, spontaneous, and intuitive when used outside more conventional scenarios (e.g., games), and differently from other paradigms of interaction, it must be explicitly explained to the users to be discovered, learned and used

Acknowledgements

This work is partially supported by the EC program EIT Digital under project "High Impact Initiative Street Smart Retail 2015". Authors are grateful to Philips Research for their contribution to this study.

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