POSTER: Reducing the Electricity Consumption of Large Outdoor LED Advertising Screens

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ABSTRACT

Outdoor LED advertising screens have a high power consumption. Those installations can easily reach a power density of 1kW per square meter. This causes not only high electricity costs for the operator but also pollutes the environment with stray light. As the high power consumption is mainly caused by incorrect brightness settings, better control loops could improve the situation. In this paper we propose first steps towards improved brightness control loops which could lead to significant reductions of power consumption as well as stray light. A first evaluation shows that our proposed solution reduces the power consumption of large LED advertising screens by up to 25%.

1. INTRODUCTION

Outdoor LED advertising screens have become ubiquitous inhabitants of modern metropolis. While the exact number of such displays is unknown, according to a Panasonic study, the annual business volume of this market is as high as $1 billion with a growing rate of 20%. With a peak power density exceeding $1kW$ per square meter display area, each of these wall displays consumes huge amounts of electricity and pollutes the environment with stray light [1]. This raises the question, whether there are opportunities to save a significant amount of energy. In this paper we analyzed the power consumption of such screens to determine the saving potential. As result, we identified incorrect brightness settings as main factor for electricity wastage. Building upon that, we developed a better brightness control schema based on the outdoor luminance. First evaluations of this schema show a 25% decrease in the power consumption.

2. STATE OF THE ART

State of the art outdoor LED wall systems as shown in Figure 1, consist of the LED wall itself and a Control Unit. Typically, a computer running a special playback and control software is used as Control Unit. This system sends the video signal to display and also control commands to the wall screen. The most commonly used Control Units could adjust the brightness setting in 100 discrete steps. There exist two strategies to adjust the brightness of the LED wall:

1. Time Table based: The brightness of the display is set to a specific value depending on the current date and time. Such time table based algorithms allows reducing the luminance during night times. Although easy to implement, such control algorithms could not achieve optimal control, because they do not consider the actual outdoor luminance.

2. Outdoor luminance based: Newer LED wall screens are equipped with sensors to measure the actual outdoor luminance. As those sensors are mainly developed to reduce the intensity of stray light, their Control Units could switch the brightness in only eight discrete steps. Therefore, a detailed investigation analyzing the energy efficiency of those solutions is required. As shown by [3] such an approach could lead to significant energy savings.

Both brightness control strategies yield suboptimal results from an energy consumption point of view. Thus, in the following sections, we will illustrate solutions to reduce the power consumption of such outdoor LED advertising displays.

3. ADAPTIVE BRIGHTNESS

The goal of this work is to minimize the power consumption of LED walls without negatively affecting the perception of human spectators. Technically spoken, our optimization aims are:

1. Optimal contrast for human spectators.
2. Minimal power consumption.
3. Minimal stray light pollution.

Similar to Moshnyaga et al. [2], we sense the luminance and use a characteristic curve to calculate the brightness setting. Then our solution automatically adjusts the brightness according to the previously calculated setting. This process is shown in Figure 1.

To achieve our optimization goals, the sensor for measuring the outdoor luminance should have a luminance resolution as high as the humans eye together with a high dynamic range. As stated in the Weber-Fechners Law, the human eye responds logarithmically to visual stimuli. Therefore, we decided to use the image data of a video camera for calculating the outdoor luminance. State of the art video equipment is heavily optimized to match the perception characteristics of the human eye and thus yield good luminance readings.

For optimal control, the characteristic curve of the brightness controller should match the logarithmic luminance perception of the human eye. Otherwise, the controller adjusts

e-Energy'14, June 11–13, 2014, Cambridge, UK.
ACM 978-1-4503-2819-7/14/06.
http://dx.doi.org/10.1145/2602044.2602071.

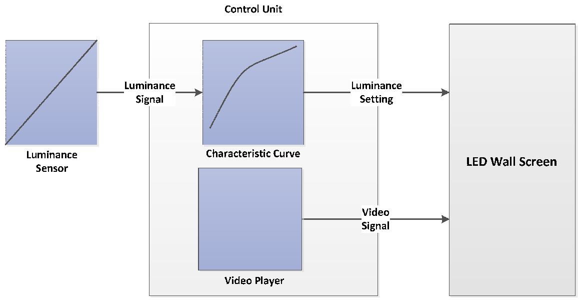

Figure 1: Overview over system setup.

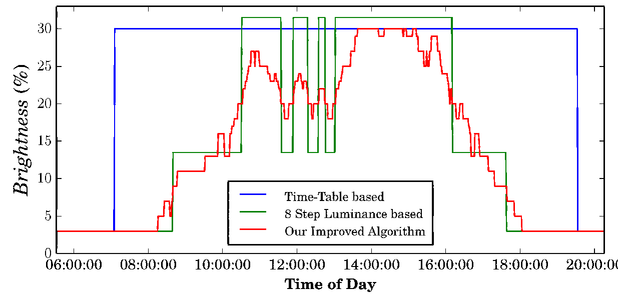

Figure 2: Brightness for different control algorithms

the brightness level too high in dark environments and too low in case of full sunlight. We implemented different approximations for the brightness control curve and adjusted the exact coefficients by manual fine tuning. To do so, we visually inspected and adjusted the brightness setting of the outdoor LED wall under different luminance conditions within one week. A detailed explanation of these algorithms will be omitted due to the space limitations.

4. EVALUATION

The goal of this work is twofold. First, we determine the electric wastage caused by incorrectly controlled LED wall screens. Second, we evaluate our methods for optimal brightness control. Thus, we compare our improved brightness control algorithm with state of the art solutions. To do so, we simulated the power consumption caused by different control algorithms. Building upon that, we conduced measurements in a real world deployment to validate our simulative results.

4.1 Simulation Results

To simulate the power consumption of LED walls, we measured the electricity of a 17 square meter LED wall screen showing a white picture in relation to its brightness setting. As expected, the power consumption rises linear with an increasing brightness setting x: $P_{LED}(x) = ax + b$. In case of our LED wall, the coefficients are $a = 188.3\frac{W}{step}$ and $b = 2,761W$ for x in $[0...1]$. Using this power consumption model of the wall screen, we simulated the energy demand of different brightness control algorithms under varying light conditions. The response of state of the art algorithms is shown in Figure 2. Obviously, those algorithms neither produce optimal brightness contrast for human spectators nor are they energy efficient. Our improved algorithm consumes round about 36% less energy than the time table based algorithm. Currently, our simulation model has certain limitations. It uses the actual brightness setting as input parameter but ignores the currently shown image completely. This setup might work well for LCD-based systems whose energy consumption is nearly independent from the currently shown image. For LED-based displays, it causes a certain error, because each pixel has multiple LEDs and depending on the actual color of the pixel, these LEDs are controlled individually. We addressed this issue by using the same image for all simulations. However, a future energy model might include additional parameters derived from the image to display. Those parameters could be the image brightness, a sub-sampled version of the image or the image itself.

4.2 Measurement Results

Our simulation does not consider the fact, that different images shown on the display cause differences in the power consumption. Thus, the saving potential calculated by the simulations is too optimistic.

To get meaningful results, we measured the influence of different brightness control algorithms on the power consumption of a real LED wall screen over the period of one month. During this period, the weather conditions ranged from bright sunlight shining directly on the LED wall screen to dark and rainy days. Compared to the time table based brightness control algorithm our solution reduced the power consumption of the LED wall screen in average by 25%. However, this saving potential should be taken as approximation value - the actual saving potential depends on the season as well as on the content shown on the display and our measurement period is too short for well founded statements. A comparison to the luminance based control was impossible to conduct, because our LED wall screen was not equipped with the required hardware.

5. CONCLUSION AND OUTLOOK

The first results show a great electricity saving potential of 25% percent by using appropriate outdoor luminance sensors for controlling the brightness of LED wall screens. This energy saving could be achieved while maintaining optimal contrast for human spectators even under different luminance conditions. To extend this work, we plan an exhaustive long term evaluation of the hereby proposed solution deployed on multiple LED wall screens of different sizes and manufacturers. Furthermore, we will conduct a user study to determine the optimal contrast setting for human spectators.

6. ACKNOWLEDGEMENTS

This work was funded by the German Federal Ministry of Education and Research. The support code of the underlying project is 01IS12054. The authors are fully responsible for the content of this paper.

7. REFERENCES

[1] Ho et al. A Study on Energy Saving and Light Pollution of LED Advertising Signs. 2011.

[2] Moshnyaga et al. A Camera-Driven Power Management of Computer Display. 2012.

[3] Venkatasubramanian. Dynamic Backlight Adaptation for Low-Power Handheld Devices. 2004.