Automatic Design of LED Street Lights

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An interesting side effect of industrial civilization - becoming an emphatic problem of our modern age - is light pollution, also known as photopollution or luminous pollution. This phenomenon is the unwanted or unneeded lighting of outdoor areas by artificial light. It obscures the stars in the night sky making impossible the observation of certain astronomical objects. Moreover, light pollution raises questions about energy conservation, a subject having an increasing importance as the world's energy consumption grows [1].

A light-emitting diode, or simply a LED, is a semiconductor light source. The colour of the emitted light can be in the infrared, visible light or ultraviolet wavelength range. Nowadays, the application of LED technology is available for street lighting purposes. It has many advantages over the commonly used incandescent light bulbs such as the lower energy consumption, the longer lifetime, or the dimmability.

Assume, that we would like to light a rectangle shaped street section by a LED street light. As a single LED can only light a small area, we have to use multiple LEDs in the lamp in order to cover the entire street section. Consequently, we need to set the direction and type of every LED to create a configuration. Rigorous regulations specify the minimum, maximum value and other characteristics of public lighting in protection of the motorists, therefore the proper design of a LED configuration is quite a challenge even for an experienced engineer. If we add the obvious expectation of economic optimality to the list, the manual design is certainly impossible.

We developed a software solution to automatize this process. Considering the lighted area of a single LED as the intersection of its sphere shaped lighting characteristic and the street section to be lighted, we are facing an interesting circle covering problem. Since we try to cover a rectangle with circles whose extent of contribution to the coverage is not just different comparing any two of them, but it is also changing within the same circle, one may undoubtedly realize that our problem is far from ordinary. To make things more complicated, we also have to take into account the effect of the neighbouring street sections based on the symmetries, hence calculating the coverage of a single configuration is not trivial too.

We approached this task as a global optimization problem. We used a genetic algorithm to find a suitable configuration. Due to the fact that the bulk of the computations are related to the determination of the actual lightings, we made parallel the independently executable parts of our calculations using NVIDIA's CUDA technology [2]. As a result, the average runtime of 3 hours has dropped to 15 minutes although we remark that the non parallelized version also provided an acceptable solution after 20-30 minutes.

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References

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[2] NVIDIA CORPORATION, CUDA technology, *http://www.nvidia.com/object/about-nvidia.html* (visited in 2014).