Poster Abstract: Solar-Powered Adaptive Street Lighting Evaluated with Real Traffic and Sunlight Data

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ABSTRACT

Street lighting is an important resource; it has been shown to reduce crime, improve road safety, and increase economic activity. These benefits, however, come with a cost: an annual emission of 64 million tonnes of CO_2. Solar-powered street lighting is attractive for its use of renewable energy and its ease of installation (particularly in off-grid applications), but sizing and control is a non-trivial task. This paper describes TALiSMaN-Green, a traffic-aware street lighting scheme which takes account of road users as well as the available energy to dynamically adjust lighting levels. Simulations using real traffic and sunlight data illustrate that solar-powered streetlights can be managed to deliver consistent usefulness throughout the night.

Categories and Subject Descriptors

J.M [**Computer Applications**]: Miscellaneous

Keywords

Energy prediction; street lighting

1. INTRODUCTION

In our previous work, we proposed TALiSMaN, a scheme for dynamically managing streetlight brightness using a distributed network of road-user sensors [2]. The scheme considers the lighting needs of motorists and pedestrians by dynamically setting lighting levels while also trying to minimize energy consumption. The decentralized scheme works wirelessly, with each streetlight transmitting to its neighbors when it senses a road user in its vicinity; the surrounding streetlights then set their light levels appropriately. Simulation results indicate an ability to reduce the energy consumption of streetlights by 45-98% (depending on traffic volume) without affecting usefulness.

Solar-powered streetlights have the potential of offering lighting to off-grid areas (e.g. rural locations), but pose the added complication of having a finite supply of energy at the beginning of each night. When TALiSMaN is used with solar-powered streetlights, if enough solar energy was not harvested during the day, the battery becomes suddenly depleted at which point the light is turned off. TALiSMaN-Green [2] was developed to address this. Energy demand and streetlight operational hours are predicted using machine learning. The scheme (Figure 1) uses these predictions, along with the charge status of the battery, to condition the brightness level requested by TALiSMaN to ensure it continues operation (at reduced brightness) until morning.

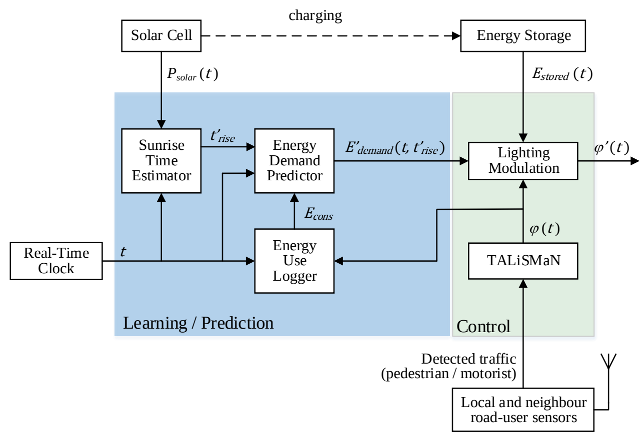

Figure 1: The TALiSMaN-Green control scheme.

While TALiSMaN-Green was shown to be effective, its evaluation made some two approximations: 1) road users were modeled using synthetic data estimated from abstract and under-sampled estimates of vehicle traffic, and 2) harvested solar energy was modeled assuming a constant initial battery charge on every evening and on every streetlight. As the success of TALiSMaN-Green depends on the effectiveness of the machine learning algorithms, these approximations may be unrepresentative of real performance. Here, we present the results of evaluating TALiSMaN-Green with real traffic and solar data.

2. EVALUATING TALISMAN-GREEN

TALiSMaN-Green was evaluated using StreetlightSim[1], a simulation environment which couples OMNeT++ network simulation with road user simulation. To model traffic, real

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[1]The StreetlightSim tool is available to download from `http://www.streetlightsim.ecs.soton.ac.uk/`

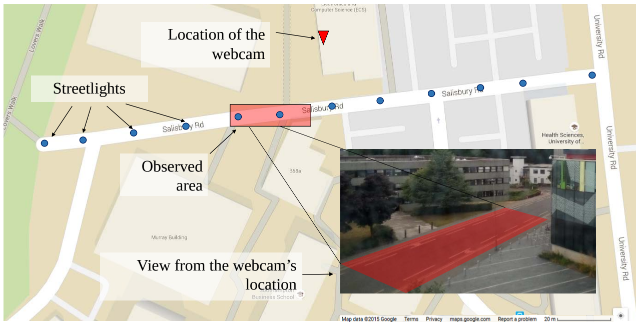

Figure 2: Data collection set-up and evaluation scenario.

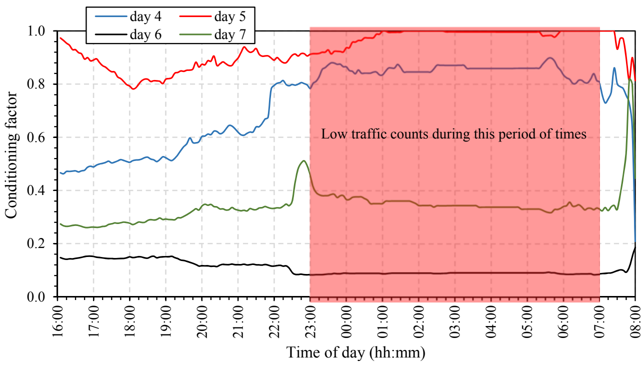

Figure 3: Conditioning factor for a single streetlight across several days of the evaluation period.

data was collected over a continuous six-week period in late winter 2015. A camera was placed in a window overlooking the road (Figure 2), and the video processed [3]. To model harvested energy, real solar radiation data [1] was used from a similar six-week winter period to estimate how much energy could be harvested on each day. To vary the amount of energy harvested by each streetlight (representing local spatial variation in sunlight, e.g. due to shadowing), a random attenuation factor was applied. Solar panel and batteries were sized to enable all-night operation with TALiSMaN, assuming average sunlight levels for a typical winter day.

3. RESULTS

Figure 3 shows the conditioning factor for a streetlight on several days of the test (a factor of 1.0 represents normal TALiSMaN operation, whereas <1.0 represents additional throttling of the brightness to manage the night's energy budget). Each day, variations in available solar energy mean the streetlight's batteries get charged to different levels; this results in a different initial conditioning factor every day. A gradual adjustment of the conditioning factor can be seen: this is normal operation, as the scheme acts to predict likely energy use and continually revise the conditioning factor in response to observed behavior. As Figure 4 shows, the streetlights only become depleted a few minutes before the 8am sunrise; this contrasts with conventional TALiSMaN, where 50% of the streetlights are depleted by 22:00. Figure 5 shows the usefulness of street lighting: TALiSMaN-Green's remains consistent throughout the night, while conventional TALiSMaN's drops significantly.

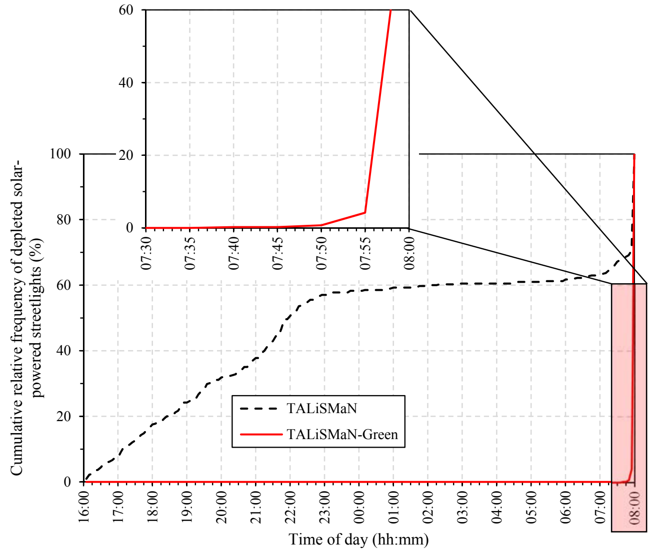

Figure 4: Proportion of solar-powered street lights which are not operational (because they have depleted batteries).

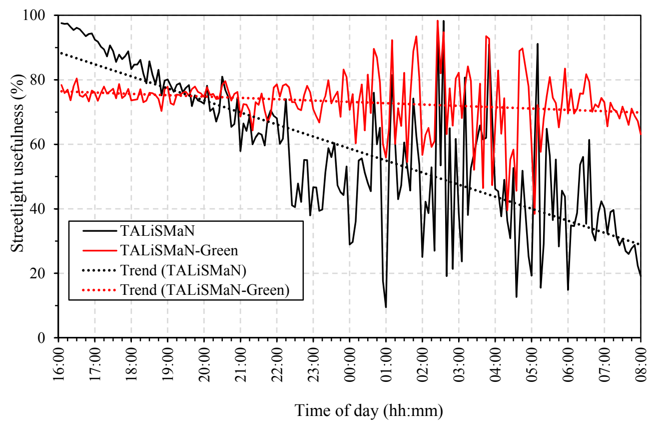

Figure 5: Mean streetlight usefulness experienced by users.

4. CONCLUSIONS

The effectiveness of TALiSMaN-Green has been evaluated using real sunlight and road traffic data, and has been shown to manage the operation of solar-powered streetlights to maintain consistent usefulness throughout the night.

5. REFERENCES

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