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CoolWalks

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Extended Abstract

Every year, humanity is experiencing hotter and hotter summers, with the ongoing climate change identified as a driving factor behind this development [1]. Beyond the general discomfort experienced by prolonged stay in direct sunlight and hot temperatures, there are many health related issues associated with it as well, such as sunburn, increased risk of skin cancer, dehydration, exhaustion and even heat stroke [2]. The most often given advice on how to alleviate these problems is to either apply and reapply skin protection in generous quantities, or to avoid long stays in direct sunlight and heat as much as possible. But exactly how easy is it to implement the latter advice in our cities in the context of mobility, especially during times of high sun intensity?

Inspired by previous works on human centric routing based on beauty, happyness and quietness [3, 4] and the release of a routing app created by the city of Barcelona [5], showing the general interest in understanding shadows as a tool to make traversing cities more comfortable, we set out to systematically study how the shade available to pedestrians at different times of day affect the implementability of advice such as "staying out of the sun" on the block, neighbourhood and city level.

We introduce a linear model for the perceived length of a street

$$d^{\alpha}_{i\to j} = (1-\alpha)d^{\text{sun}}_{i\to j} + (1+\alpha)d^{\text{shade}}_{i\to j} \tag{1}$$

where $d^{\text{sun}}_{i\to j}$ and $d^{\text{shade}}_{i\to j}$ represent the total length of the street that is exposed to sun or in shade, respectively. The value $\alpha \in (-1,1)$ weights the lengths of shaded parts of the street against sun-exposed ones, effectively tuning the importance of staying in the shade. For example, $\alpha \approx 1$ is full shade seeking, $\alpha = 0$ is indifference to shade, while $\alpha \approx -1$ models full sun seeking.

By finding the physical length of all to all shortest paths in this distance measure for various values of α and times, we approximate the performance of the street network when the total available amount of shade decreases and the need for cover from the sun increases.

We then expand on the insights gathered in this step by asking if there appear relations between the local "shade deprivation" and other measures, such as socio-economic properties of the neighbourhood, or geometric properties of the network. Lastly, we propose methods to identify streets and neighbourhoods with a high shade deprivation in order to help urban planners prioritise when developing shading-solutions to brace for the inevitable worsening of climate change.

The basis of our shadow generating pipeline is formed by two datasets, one containing building-footprints with their respective average height and the other one containing data on the location and morphology of trees in the given city. Using a simplified version of an algorithm devised by Grena [6], we calculate the position of the sun, which combined with the tree and building data, allows us to approximate the shadows cast by the individual objects. Combining these resulting shadows with street networks from OpenStreetMaps, we extract detailed information on the structure of the shadows cast on each street. An overview of the datasets and processing results is given in Fig. 1.

We developed the above methods on the area of Clifton, a small suburb south west of Nottingham (UK). The dataset includes 2989 buildings and 7305 trees, spread over an area of about 12 km^2. The street network contains 1692 nodes and 226 km of sidewalks. We are expanding the study to larger and more varied cities, like London, New York, or Barcelona, to capture and study a large variety of different networks and building morphologies.

Understanding the effectiveness of shade in cities as a potential way of reducing heat and sun exposure for citizens is a key strategy in urban climate adaptation. We further explore whether different street topologies perform inherently worse than others in providing shaded living environments, and whether we can find relations between the shade deprivation and various socio-spatial properties. City planners will be able to use these tools to evaluate the current shade deprivation of their streets and neighborhoods to develop actionable plans to efficiently decrease it. Given the results of this study many extensions and improvements are imaginable. One could for example take the individual perspective, and explore how humans change their routing decisions when the sun exposure and temperatures change, and how well those correlate with our model.

References

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