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Extended abstract

Exploring the value of user-generated app data to design and improve urban running environments

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Sedentary behavior, physical inactivity and the concomitant health concerns have made increasing physical activity one of the grand societal challenges in most of the western world [1, 2]. Promoting healthy and active lifestyles is therefore a contemporary topic in both government practice as across multiple disciplines in research (e.g. in the fields of sports studies, urban design, geography, sociology and psychology) [3].

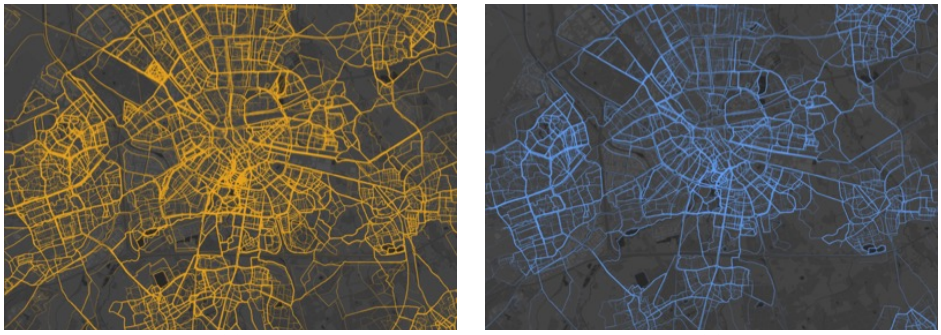
There is ample evidence that for people, physical activity is influenced by individual, social and environmental factors [4–7]. In this study, we focus on the environmental influence and how this can contribute to a healthier and more active society. Focusing on convenience, transport and 'practical' matters, larger cities and metropoles have not necessarily developed with this in mind [3], even though a pleasant, 'healthy' environment stimulates the health, happiness and welfare of the people using it. Since the design and layout of urban areas have the potential to contribute to a more active and therefore improved lifestyle [7], local and national governments can provide focus on health values through their urban planning. We write this paper from a perspective of sports and urban planning and reflect on the value that large-scale GPS running datasets can have in this field.

In Europe, running is by far the most practiced sport [8–10]. Where, how and why people run is notably influenced by urban layouts [7, 11]. In this paper we aim to create an insight in the extents of this influence, using GPS trail data collected from the *Start2Run* [12] (Belgium) and *Hardlopen met Evy* [13] (Netherlands) running apps from Energy Lab. These apps together have collected data of almost 2.1 million runs, ran by approximately 230.000 users between 2012 and 2016. The apps intend to motivate (novice) runners to run by providing training schedules and feedback and offer them insight into their running patterns. Next to full GPS trails of each run, the dataset contained accompanying metadata for each run, including a run- and user-id, timestamp, the distance, duration, average speed and effective time (running time minus stopping time) of the run and a training-id if a specific training program of the app was followed.

In this study, we explored how this type of user-generated data could help to define what makes an ideal running environment and how this could contribute to creating public spaces for a better running climate [14]. We used a mixed-data source approach to collect data for this research. We first used the large-scale dataset of GPS trails to find running *'hotspots'*, and *'coldspots'*. To do this, we used interactive data visualizations as a tool to quickly explore and recognize possibly interesting locations patterns for research. We created maps showing the running locations, first on a large scale, showing general spread in a large area with only the starting point of each run. These maps showed several hotspots, that coincided perfectly with the most populated areas; the largest cities in the Netherlands and Belgium. When zooming in on these cities, the full GPS trails were added, showing exact running locations. This way we could quickly locate and evaluate different places in different cities. The hotspots and coldspots on these maps showed the exact locations that are preferred or avoided by runners. This showed that in general most hotspots coincide with green or water (parks in urban areas).

Subsequently, we computed extra attributes to enrich the running data, including derivatives of the timestamp (time of the day, day of the week and month of the run), but also whether the run took place during the day or at nighttime (merged with sunrise and sunset times), in what kind of weather (merged with meteorological data) or in what type of neighborhood (indicated by real estate value in area of the run).

When visualizing the GPS trails while coloring or hiding all runs with specific characteristics, different patterns emerge for different times or different circumstances. By comparing these maps, we see that preferred running routes can differ notably from one map to the next, indicating that running patterns change over time or with circumstances. A clear example can be seen in the daylight and nighttime maps (Figure 1), some popular spots during the day are completely avoided after dark. Visiting some of these spots showed that the presence or absence of streetlights is probably an important factor in these changes, together with places being more or less remote or inhabited. Another example is shown when comparing the rain runs and dry runs. Not only do we see a noticeable decrease in runs during rain in general, we also again see differences in where the most popular running spots are. In the Hague, for example, the coastline is a much-used running track when it is dry, but hardly used when it rains. From analysis and comparisons of these maps we can not only derive strong indications of which environmental factors appeal to runners, we can also see the influence of changing circumstances on running behavior and how this varies over time. This provide new and valuable insights in running patterns and behavior.



(**a**) (**b**)

Figure 1. Visualization of GPS running trails in Eindhoven of runs: (**a**) during daylight hours; and (**b**) after nightfall.

With these findings we show that this previously unavailable user-generated data can give clear insight into how current urban spaces are used and in how the actual users respond to the urban areas they inhabit. These we can use to understand better which environmental qualities contribute to an appealing running climate so that we can create healthy and active urban spaces that accommodate, encourage and attract urban runners.

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