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Exploring Spatio-Temporal Event Data on a Smart Watch

Annika Bonerath [a,*], Lukas Temerowski [a], Sven Gedicke [a], Jan-Henrik Haunert [a]

[a] *University of Bonn, bonerath@igg.uni-bonn.de, s7luteme@uni-bonn.de, gedicke@igg.uni-bonn.de, haunert@igg.uni-bonn.de*

* Corresponding author

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Abstract:

Given the trend of small screen devices such as smart watches, we need to think of new concepts for visualizing information on limited space. In this paper, we specifically focus on circular displays as often found for smart watches. In particular, we look at the visualization of spatio-temporal event data. As an example, take the scenario of a city festival with attractions taking place at different locations and times. Each attraction can be understood as an event. During the visit of such city festival a visitor might frequently look for the next nearby attractions. Visualizing this information on a smart watch enables the visitor to explore the attractions effortless.

In this paper, we look at such a visualization. In detail, our visualization consists of two components: a map in the center and a circular timeline (similar to a clock) at the boundary of the screen; see Figure 1. We place two markers for each event; one marker is placed at the spatial location on the map and one marker at the timestamp on the timeline. In order to allow the user to associate the two markers of one event, a connecting line, which is commonly called leader, is drawn. Note that this kind of visualization is known as boundary labelling. However, previous work has focused on map boundary labelling for non-temporal data (Gedicke et al. (2020)).

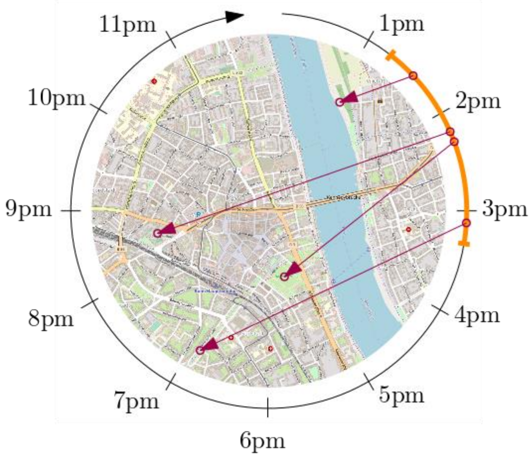

Figure 1: Map, timeline, time-window slider, and four events. Data by OpenStreetMap, under ODb

In our approach, we integrate a dynamic query interface into our visualization. This interactive component allows the user to filter the data with a time-window slider. For example, in our use-case, a city festival visitor might only be interested in the attractions that happen in the next two hours. In this paper, we restrict our time-window slider to a fixed size. The time-window slider can be slid around the time line such that only time markers inside the time window are connected to the corresponding markers on the map.

Although, due to the time-window filtering, only a subset of events may be visualized, it still may result in a confusing illustration with a high number of leader crossings. Hence, we want to visualize only a selection of events in the time window. From static map labelling inspired, our model comprises two optimization goals; on the one hand we want to maximize the number of displayed leaders over all time windows while on the other hand we want to minimize leader crossings over all time windows. A problem related to the interaction are flickering leaders, i.e., a leader that repeatedly appears and disappears when continuously sliding the time window. These flickering effects are shown to be distractive for users. We particularly forbid such flickering in our model by limiting each leader to appear and disappear at most once.

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We approached the presented problem by introducing a data structure that we pre-process from the events. Following Been et al. (2010), our data structure associates a so-called activity interval to each event such that whenever the starting time of the time-window slider lies in the activity interval, the event's leader is displayed. With this data structure we can forbid flickering and optimize the two presented objectives. We provide a formulation of our model as a mathematical integer linear program. Another advantage of pre-processing the data into a data structure is the efficient query time that allows real-time applications.

We evaluate our model using real-world data. It shows that, for such a real-world data set, we can pre-process the data structure in a reasonable time. We also provide an analysis of the weighting between the two optimization goals. Further, we compare the data structure to a heuristic approach.

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