SPOT: Simulation and Evaluation of Real Time Locating System Data

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Abstract. The demo of SPOT introduces the location analytics platform that allows us to gain insights into location data and visualize it on a map. The demo is targeted at academics and industry people who are interested in insights that we can obtain from analysing location data in a business context. Location data becomes increasingly accessible in many settings due to the uptake of the internet of things and the availability and spread of sensors in our connected world.
The demo gives an overview over the features of SPOT, its input data model, and also highlights the real-time-locating system simulator that is able to generate realistic product and user data for a randomly generated store.

Keywords: location analytics · trajectory clustering · visualization · operational decision making

1 Significance

Event data plays an important role for designing, executing and monitoring business processes. Various automatic analysis techniques have been recently developed in the area of process mining in order to extract knowledge from these process-related event logs. Typical scenarios in this context make use of the symbolic information about the type of event, its timestamp, its relation to a case identifier and data of the objects that are processed. What is to a good share neglected by process mining is the integration of location-related data (with [1] and [4] being among the rare exceptions).

Location information is a prominent by-product of many business processes and their support systems [5,6]. Starting with GPS positioning in open areas, the location is an important context of our life and the activities we perform. Smart homes, public cameras, RFID real-time locating systems, BlueTooth-enabled sensors and similar devices capture data about our location and movements, which can be integrated in location-aware business processes [3,5,6].

In this demo, we showcase the functionality of SPOT. While classical process mining tools visualize and abstract the most important logical steps, SPOT is meant to support the monitoring and analysis of business processes that are fully or partially tracked in a location-aware way. Thus, we explicitly support customer shopping processes in brick-and-mortar retail shops, patient flows in hospitals, as much as logistic transportation processes. The contribution of SPOT is a novel set of analysis features such as comparing differences in movement patterns, projecting aggregate KPIs on the map, clustering trajectories and inspecting utilization of resources (e.g., fitting room cabins, surgery rooms) for better planning.

The rest of this demo paper is structured as follows. Section 2 describes the maturity and features of the tool. Section 3 lists the website with a screencast. Section 4 introduces the data model and simulator that provide the input for analysis, before Section 5 concludes.

2 Maturity

SPOT is in a prototype phase of development and therefore is not meant to be used productively right now. However, the list of features is almost as complete as known from competing industrial analytics tools. SPOT supports the lifecycle of location data analytics. Once we collected the data and imported it into the data model underlying SPOT, we can start with the analysis of the data. Figure 1 shows how frequency of visits is projected to the map.

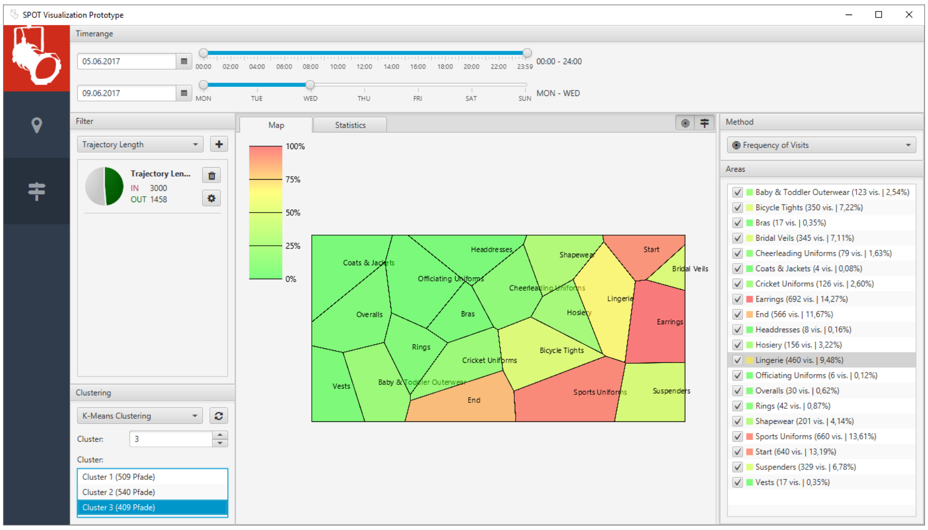

Fig. 1: Screenshot of the Tool highlighting the frequency of paths through a simulated shop.

2.1 Location Analytics Features

The analysis resulting in Figure 1 comprises four steps that all serve to achieve the insights of interest:

Scope The first step is to select the time frame of the analysis (i.e., we slice the data). The analyst can select a start and an end date to set the temporal scope of the data that we want to understand better.

Filter To focus on certain cases only within the scope, we can optionally filter the selected cases. Filters allow us to logically specify criteria that need to be met by the selected cases. By adding additional filters in a filter chain, the results get reduced to only the cases of interest. Example filters include duration, length, logical filters to require or disallow filtered cases to have visited certain areas, or boundary locations.

Partition The cases that passed the scoping and filtering step can be automatically partitioned into similar groups. This step is especially helpful for understanding location data that is generated by different processes or variants. By clustering the data into similar groups, the resulting partitions can be visualized alternatively, such that direct comparison becomes possible.
We implemented k-means clustering using a set-abstraction based similarity measure on the visited locations. Also, we support the trajectory clustering algorithm presented in [2]. Latter groups similar trajectories by their shared sub-trajectories that are densely frequented.

Visualize The visualization of all the paths that made it through the previous steps might still lead to cluttered results. Therefore, in the final step, we can hide certain aspects of the trajectories to focus on the most interesting parts. Thresholding by frequency and duration allows us to quickly see the most frequented passages in the selected trajectories, or the most popular areas on the map. The visualization currently focuses on three aspects: *aggregate measures* for locations (frequency of visits / total duration of stay / avg. duration of stay), *aggregate paths* (i.e., transition frequency), and *individual paths*.

The use cases of SPOT are manifold. We like to think of it as the swiss army knife of location data analytics. It can be used to understand single chunks of location and path data, but also to contrast two or more clusters. Latter is especially interesting in before-after comparisons. For example, the effect that a marketing campaign had on the location trajectories in the store can be displayed by comparing the average positions. SPOT provides answers to: "How much more frequent are the visits to the area which contains the marketed items?", "How much more time is spent in front of posters?" That means, it becomes possible to distinguish a marketing effort that does not impact customer behaviour at all from marketing efforts that arouse interest in the product (i.e., it was more often/longer frequented), but the product does not end up being bought more than before.

SPOT is currently meant to be used by analysts in isolated sessions. Because the functionality of using SPOT is only reading and not writing data, it is no problem to have multiple analysts working on the same dataset in parallel.

3 Screencast and Website

We created a 10 minutes screencast to illustrate the functionality of SPOT and to guide the audience through the functionalities of the tool. The screencast is available at the project web site at `https://ai.wu.ac.at/spot/`. The project website also shows additional screenshots and offers the SPOT framework for download. It is free for use in non-commercial settings.

4 Data Input and Simulator

The input data model that SPOT uses is depicted in Figure 2. On the left side, we have the dynamic part showing the paths that consist of individual reads at certain areas and exact positions. These reads are located at certain positions. Positions which can belong to areas that are defined on the right hand side of the figure. Areas can be composed and have a label for distinction.

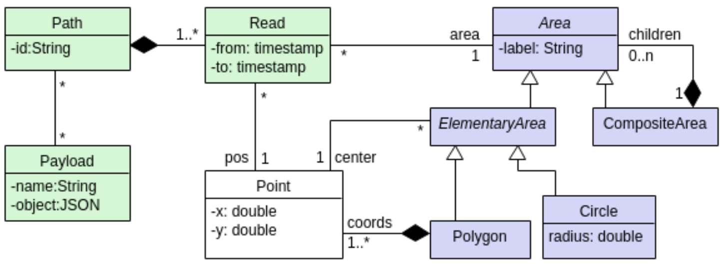

Fig. 2: UML class diagram of the input data for SPOT.

We also provide a real-time locating system (RTLS) simulator to enable interested users who would like to try SPOT but do not have the sensing infrastructure or real location data at hand. The simulator allows us to experiment with SPOT in a wide range of scenarios.

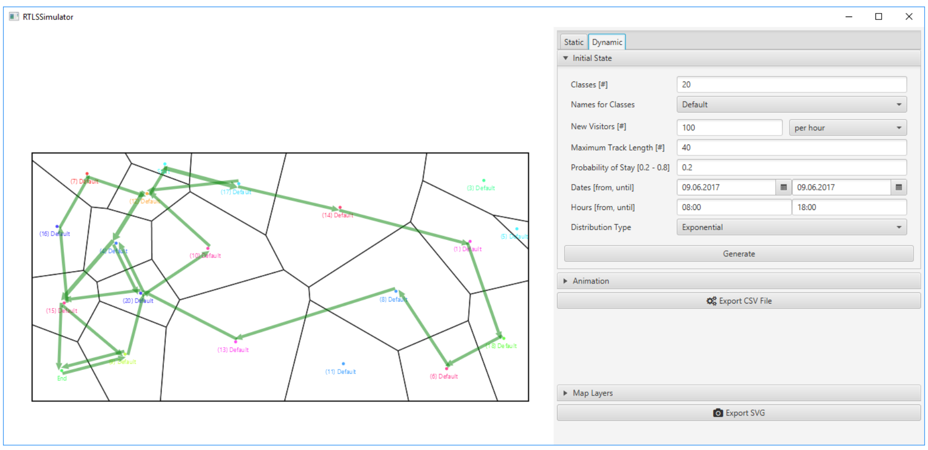

Fig. 3: Screenshot of the RTLS simulator and a random path through a generated store.

A screenshot of the RTLS-simulator is shown in Figure 3. Here, we can specify the characteristics of the generated shop and also define the desired customer behavior. That is, we can set the number of customers, the number of item categories, the interarrival times, longest paths, and other parameters. Visual inspection of the generated data and aggregate distributions allow us to quickly iterate simulations to find the desired parameter settings. The output of the simulator contains the map layout, the customer trajectories, and the area descriptions. The output can be directly loaded into SPOT for subsequent analysis.

5 Conclusion

The SPOT framework offers powerful capabilities to analyze location data from a process perspective directly on a map (or floor plan). Thereby, the focus is put on location-oriented business processes. The location data can be analyzed in four steps: scoping, filtering, clustering and visualizing location data.

The analytics framework is available for non-commercial use and can be used with the accompanying simulator that specializes on the retail use case and generates a shop layout and customer trajectories according to a number of parameters. This way, we ensure the accessibility of the framework and invite the academic community to analyze their location-centric processes with SPOT.

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