RASP: Robust Mining of Frequent Temporal Sequential Patterns under Temporal Variations - Supplementary Document

A Experiments

A.1 Setups of Competing Methods. To enhance accuracy, we created four additional versions of CAD based on the modified assumptions, statistical corrections, or statistical test methods for our experiments. Various significance levels ($\alpha = 0.01, 0.05, 0.1, 0.2$, and 1.0) were applied to all these versions of CAD, and we reported the best value obtained across all trials using all versions.

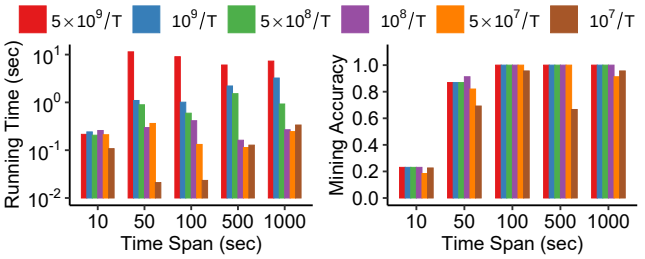
For SPADE, the number of surrogates was set to 2 × (the total number of events), and the dithering values were set to 20, 50, and 100 ms. We also reported the best value obtained across all trials.

Furthermore, we modified MIPER to be more suitable for our experiments by changing the target output from episode rules to TSPs and the significance measure from confidence to leverage.

Note that our proposed method, RASP and MIPER [1] were implemented in Java, CAD [2] was implemented in MATLAB, and SPADE [3] was implemented in C++ (FP-Growth algorithm) and Python. We identified the top-k TSPs based on their significance measures (leverage for MIPER and p-value for CAD and SPADE).

A.2 Effects of M (Max Number of TSPs to Retain). The maximum number M of TSPs to retain needs to be specified as a hyperparameter considering the total memory size and the memory size per TSP. To investigate the effect of M, we varied its value in 6 cases and measured the running time and accuracy. As depicted in Fig. 1, under **S2. Variations** (10 ms), we observed that both the running time and mining accuracy of RASP tend to decrease as M decreases. While prioritizing accuracy over speed, we fixed the value of M at $10^9/T$, where T is the time span, for all other experiments.

A.3 Results with TSPs of Various Sizes. While varying the size of ground-truth TSPs in the input data, we measured the accuracy and running times of the considered methods under the **S4. Mixed-Easy** setting. The results are given in Fig. 2, and our observations are summarized as follows:



(a) Running Time (b) Mining Accuracy

Figure 1: **Effects of the Max Number M of TSPs to Retain.** Under **S2. Variations** (10 ms), the running time and mining accuracy of RASP tend to decrease as M decreases.

- RASP outperformed all its competitors in terms of both speed and accuracy, regardless of the TSP size.
- The relative superiority of RASP in accuracy became more evident in more challenging settings (compare (a) and (b) in Fig. 2).

A.4 Details of the E-commerce Dataset. In this subsection, we describe an e-commerce dataset obtained from YOOCHOOSE Gmbh, an online retailer [4] The dataset was used in our additional experiment. The dataset was collected over several months in 2014 and consists of temporal click events. Each record in the dataset includes a session ID, an occurrence time of a temporal event instance, and an event ID, which indicates a click on a specific product. Note that session IDs were used solely for evaluation purposes and were not used as input. A summary of the dataset is provided in Table 1.

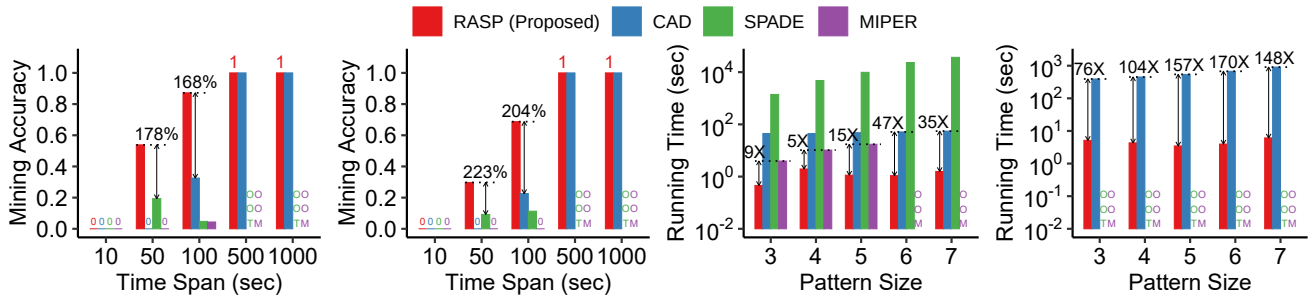
In our experiment, we focused on the temporal events that took place on April 27, a day with a high volume of temporal events. To ensure practical running time and memory usage, we limited our analysis to the 100 most frequent temporal events. We converted the timestamps from milliseconds to minutes or seconds by binning them into one-minute or one-second intervals, respectively.

[1] https://github.com/aoxaustin/MIPER/

[2] https://github.com/DurstewitzLab/Cell-Assembly-Detection

[3] https://viziphant.readthedocs.io/en/latest/

[4] https://www.kaggle.com/datasets/chadgostopp/recsys-challenge-2015



(a) Pattern Size: 6 (b) Pattern Size: 7 (c) Vs. Pattern Size (100 secs) (d) Vs. Pattern Size (1000 secs)

Figure 2: **Results with TSPs of Various Sizes.** Our proposed method, RASP, outperforms all its competitors in terms of both speed and accuracy, regardless of the TSP size.

Table 1: **Summary of the YOOCHOSE Dataset on April 27, 2014.**

Number of Events	100
Number of Sessions	53,658
Number of Temporal Events	165,118
Temporal Events per Event	1,651.18
Temporal Events per Session	3.08
Time Span per Session	259.14 secs

A.5 Set-ups of the Extra Experiments on the E-commerce Dataset. In our experiment, we set the maximum time span of a TSP L to 600 seconds, which is more than twice the average time span per session without limiting the maximum time gap δ. All other settings remained consistent with those used in the main experiments. The tolerance against temporal variations I was set to 1 minute and 5 seconds for a bin size of 1 minute and 1 second, respectively. As an additional baseline, we considered **RANDOM**, where TSPs were composed of events chosen uniformly at random.