

Online Probabilistic Interval-based Event Calculus

Periklis Mantenoglou ^{1 2} Alexander Artikis ^{3 1}
George Paliouras ¹

¹Institute of Informatics & Telecommunications, NCSR Demokritos, Greece

²Department of Informatics & Telecommunications, National and Kapodistrian
University of Athens, Greece

³Department of Maritime Studies, University of Piraeus, Greece

<http://cer.iit.demokritos.gr/>



INFORE
Interactive Extreme-Scale
Analytics and Forecasting

Event Calculus

- A **logic programming language** for representing and reasoning about events and their effects.
- Constituents:
 - **events**.
 - time model of integer **time-points**.
 - **fluents**: time varying properties, effected by event occurrences.
- Built-in representation of **inertia**:
 - $F = V$ holds at a particular time-point if $F = V$ has been *initiated* by an event at some earlier time-point, and not *terminated* by another event in the meantime.

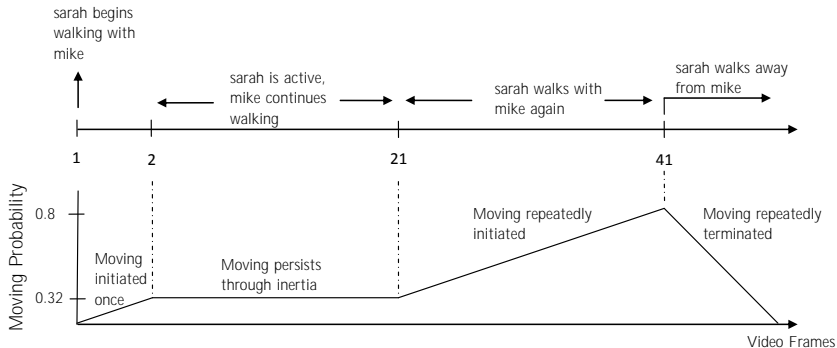
Event Calculus in Human Activity Recognition

Rules for the 'moving together' long-term activity:

initiatedAt(moving(P_1, P_2) = true, T) \leftarrow
happensAt(walking(P_1), T),
happensAt(walking(P_2), T),
holdsAt(close(P_1, P_2) = true, T),
holdsAt(similarOrientation(P_1, P_2) = true, T).

terminatedAt(moving(P_1, P_2) = true, T) \leftarrow
happensAt(walking(P_1), T),
holdsAt(close(P_1, P_2) = false, T).

Prob-EC: Human Activity Recognition



Input of Simple Events

0.70::happensAt(walking(mike), 1).

0.46::happensAt(walking(sarah), 1).

0.73::happensAt(walking(mike), 2).

0.55::happensAt(active(sarah), 2).

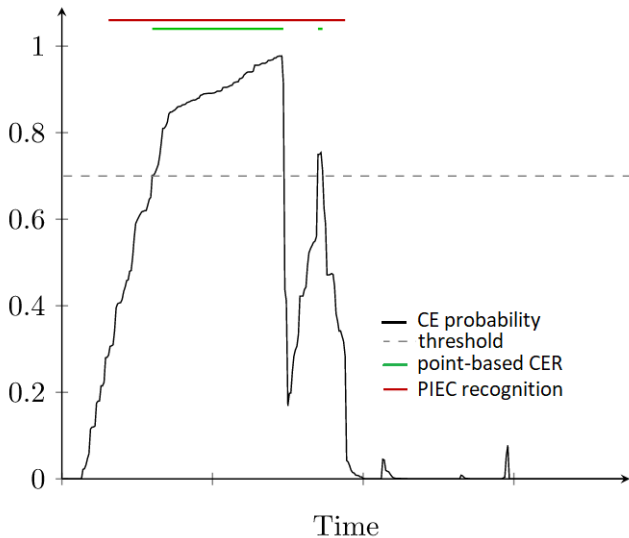
0.69::happensAt(walking(mike), 21).

0.58::happensAt(walking(sarah), 21).

0.18::happensAt(inactive(mike), 41).

0.32::happensAt(walking(sarah), 41).

PIEC: Probabilistic Interval-based Event Calculus



Interval Probability

Interval Probability

The probability of interval $I_{CE} = [i, j]$ with $length(I_{CE}) = j - i + 1$ timepoints is defined as

$$P(I_{CE}) = \frac{\sum_{k=i}^j P(\text{holdsAt}(CE = \text{true}, k))}{length(I_{CE})} .$$

Probabilistic Maximal Interval (PMI)

An interval $I = [i, j]$ is **probabilistic maximal interval** if:

- 1 $P(I) \geq \mathcal{T}$.
- 2 There is no interval $I' : P(I') \geq \mathcal{T}$ and $I \subset I'$

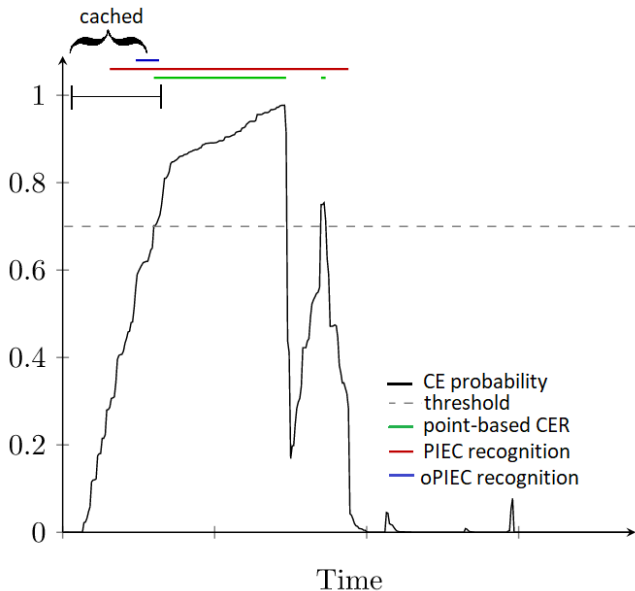
Interval Computation

Input: A temporally sorted array of probabilities of a CE.

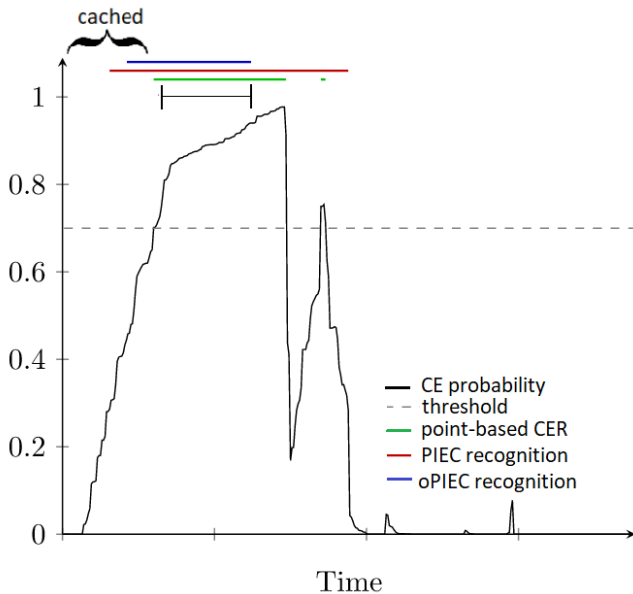
Output: A collection of probabilistic maximal intervals.

- Let t_s, t_e two indices of the input array.
- PIEC computes $prefix[t] = \sum_{i=0}^t (P(i) - \mathcal{T})$ for each index.
- If $prefix[t_e] - prefix[t_s-1] \geq 0$, then $P(I = [t_s, t_e]) \geq \mathcal{T}$.
- Then, PIEC computes every probabilistic **maximal** interval of the input in **linear-time**.

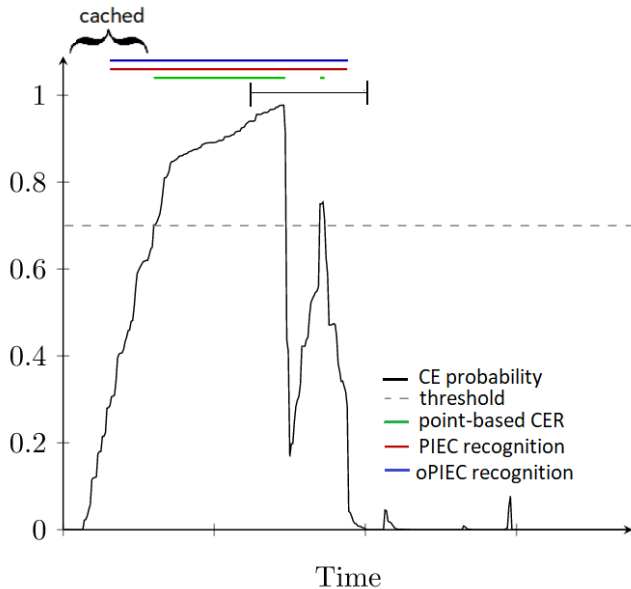
Online PIEC



Online PIEC



Online PIEC



Interval Computation – Support Set

- oPIEC computes the potential starting points of future intervals.
- The **support set** stores these starting points.
- Each starting point t_s is accompanied by the score value $score[t_s] = prefix[t_s - 1] = \sum_{i=0}^{t_s-1} (P(i) - \mathcal{T})$ used for interval computation.
- If $prefix[t_e] - score[t_s] \geq 0$, then $P(I = [t_s, t_e]) \geq \mathcal{T}$.

oPIEC^b: A Bounded memory version

- To support online reasoning, the support set must be bounded.
- oPIEC deletes the time-points with the lowest likelihood.

Support Set Maintenance

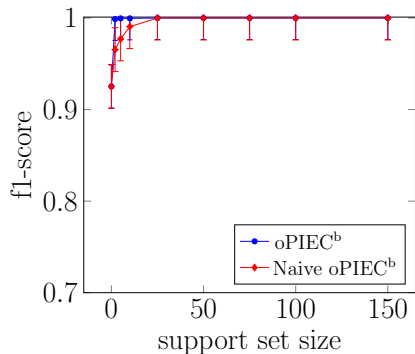
Given the support set $[(t_0, \text{score}[t_0]), \dots, (t_m, \text{score}[t_m])]$, oPIEC^b computes the likelihood L of the starting point t_i as

$$L[t_i] = \text{score}[t_{i-1}] - \text{score}[t_i].$$

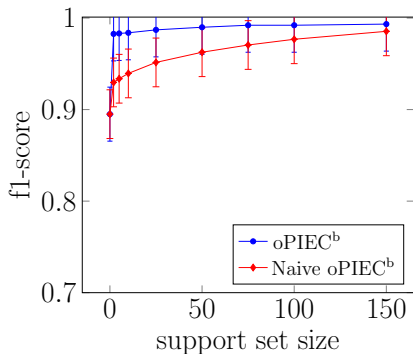
Empirical Analysis: Experimental Setup

- Empirical Analysis on CAVIAR, a benchmark dataset for human activity recognition.
- CAVIAR has been injected with artificial noise; We used a 'smooth noise' and a 'strong noise' version.
- The target CEs are: 'moving together', 'meeting' and 'fighting'.

Online to Batch System Comparison

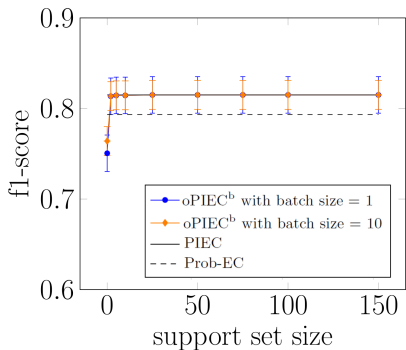


'Meeting' activity; 'smooth noise'.

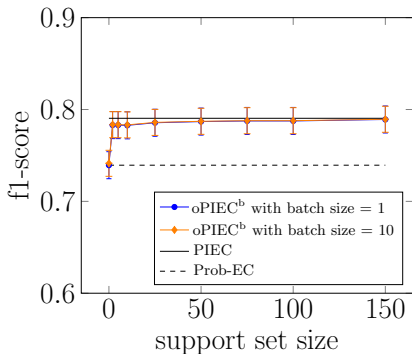


'Meeting' activity; 'strong noise'.

Evaluation against the Ground Truth



'Fighting' activity; 'smooth noise'.



'Meeting' activity; 'strong noise'.

Summary and Future Work

Summary

oPIEC:

- supports online interval-based CER.
- guarantees correct interval computation by identifying every potential starting point of a CE in a stream.
- introduces an effective memory maintenance method for storing potential starting points.

Future Work

- New support set maintenance methods.
- oPIEC on maritime data.