

Self-Monitored Detection Probability Estimation for the Labeled Multi-Bernoulli Filter

Introduction

Self-Assessment of Modules

- Enables adaptability
- May be mandatory for automated cars [1]
- Real-time evaluation of the performance based on online data

Environmental Model

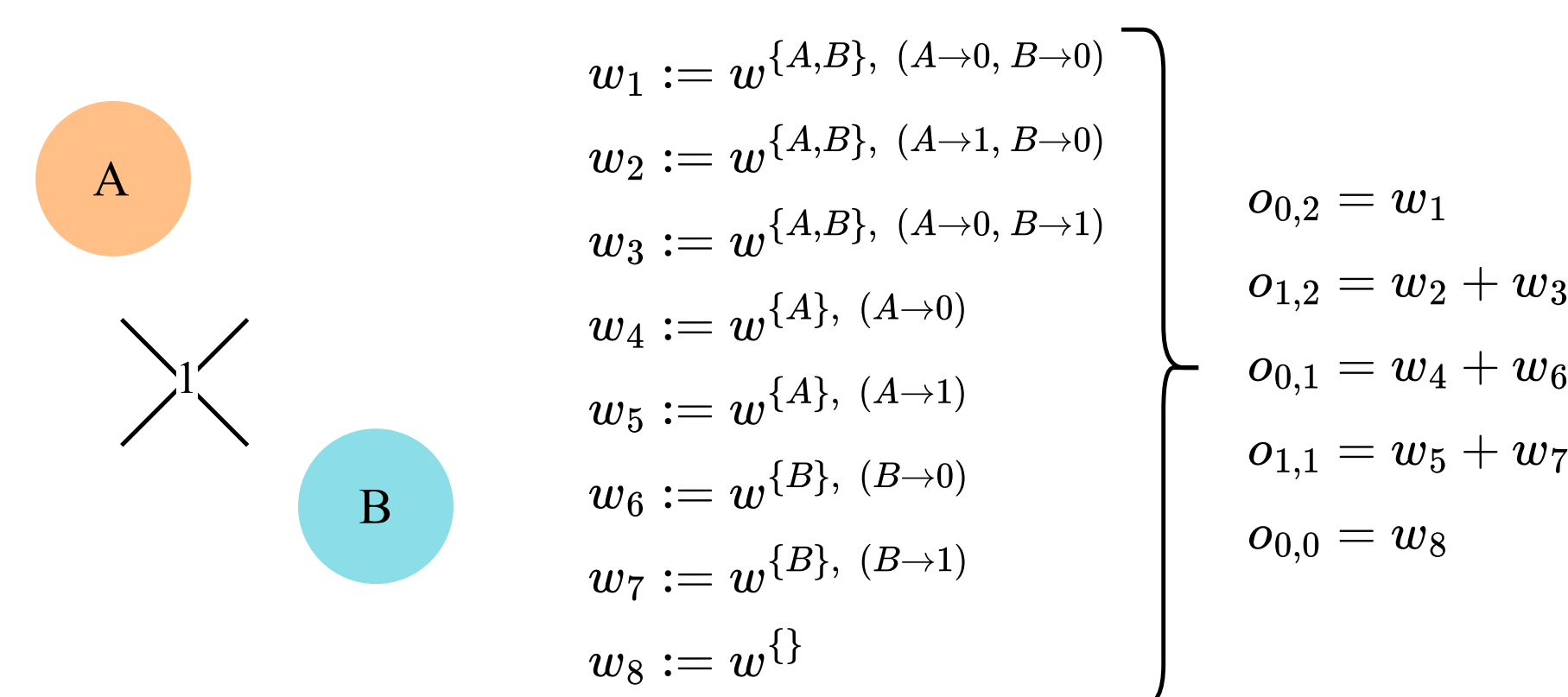
- Based on multi-sensor multi-object tracking with a labeled-multi-Bernoulli (LMB) filter [2]
- Random Finite Set based filter that considers multiple data association hypotheses
- Two major update methods
 - Update by converting LMB density to Generalized LMB density
 - Direct update of the LMB by approx. variational methods

Goals of this work

- Check filter parameters and assumptions to guarantee good filter performance
- Focus on detection probability parameter

Detection Probability Estimation Method

Distribution of the Number of Detected Objects

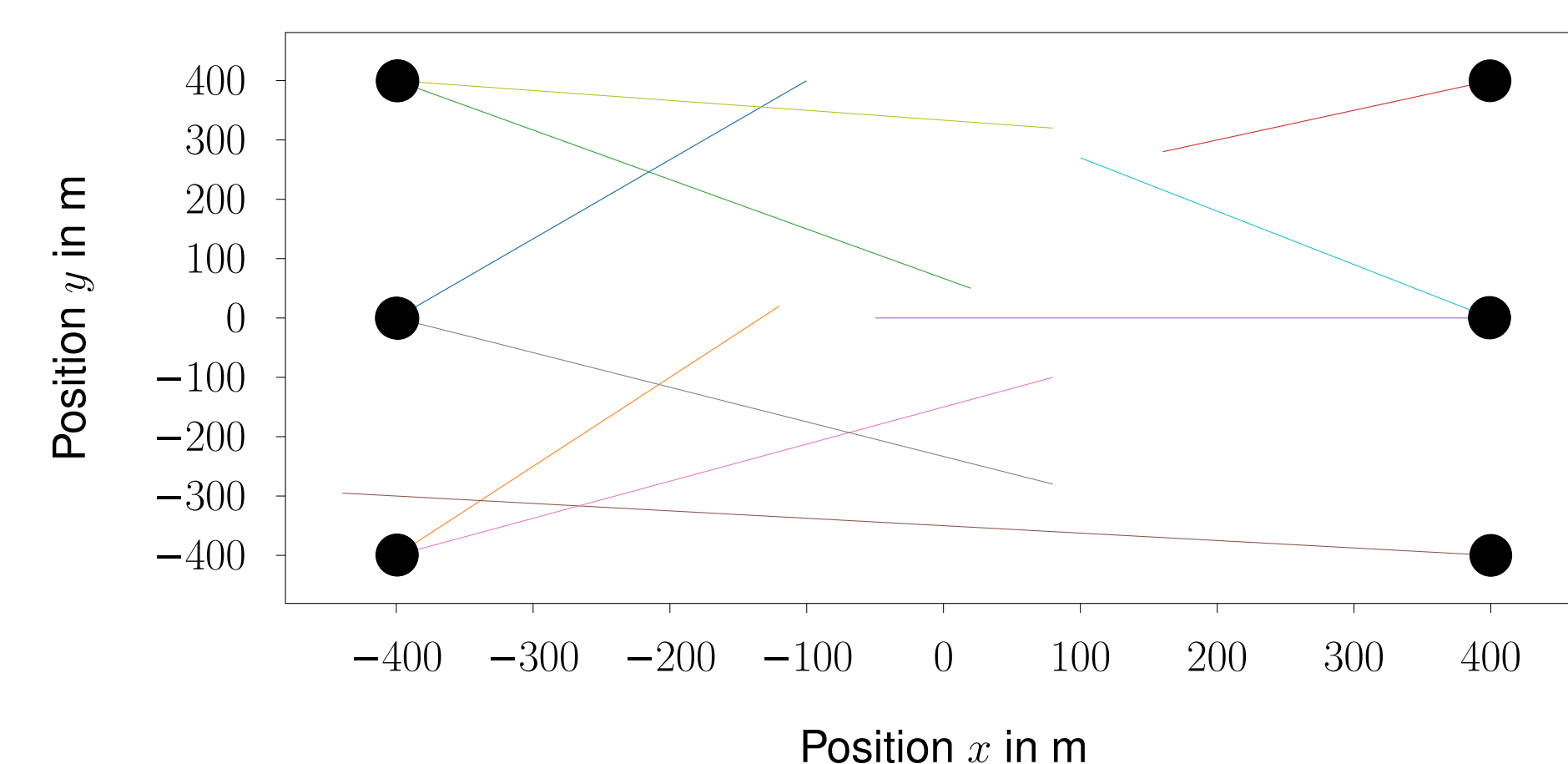


The information from the update step is used to calculate the number of detected objects. $A \rightarrow i$ denotes that track A is associated with measurement i , where $i = 0$ expresses a misdetection. $o_{k,t}$ is the probability that k out of t objects are detected.

Update of the Estimation

- Let $p_D \sim \beta(p, q)$ be the current estimation, where $\beta(p, q)$ denotes the Beta distribution with parameters p and q .
- Then, given k detections and l misdetections, $p_D | (k, l) \sim \beta(p + k, q + l)$.
- So, given Z , the set of measurements, $p_D | Z \sim \sum_{k,t} o_{k,t} \beta(p + k, q + t - k)$
- Additionally, perform merging of mixture components and introduce noise in the prediction

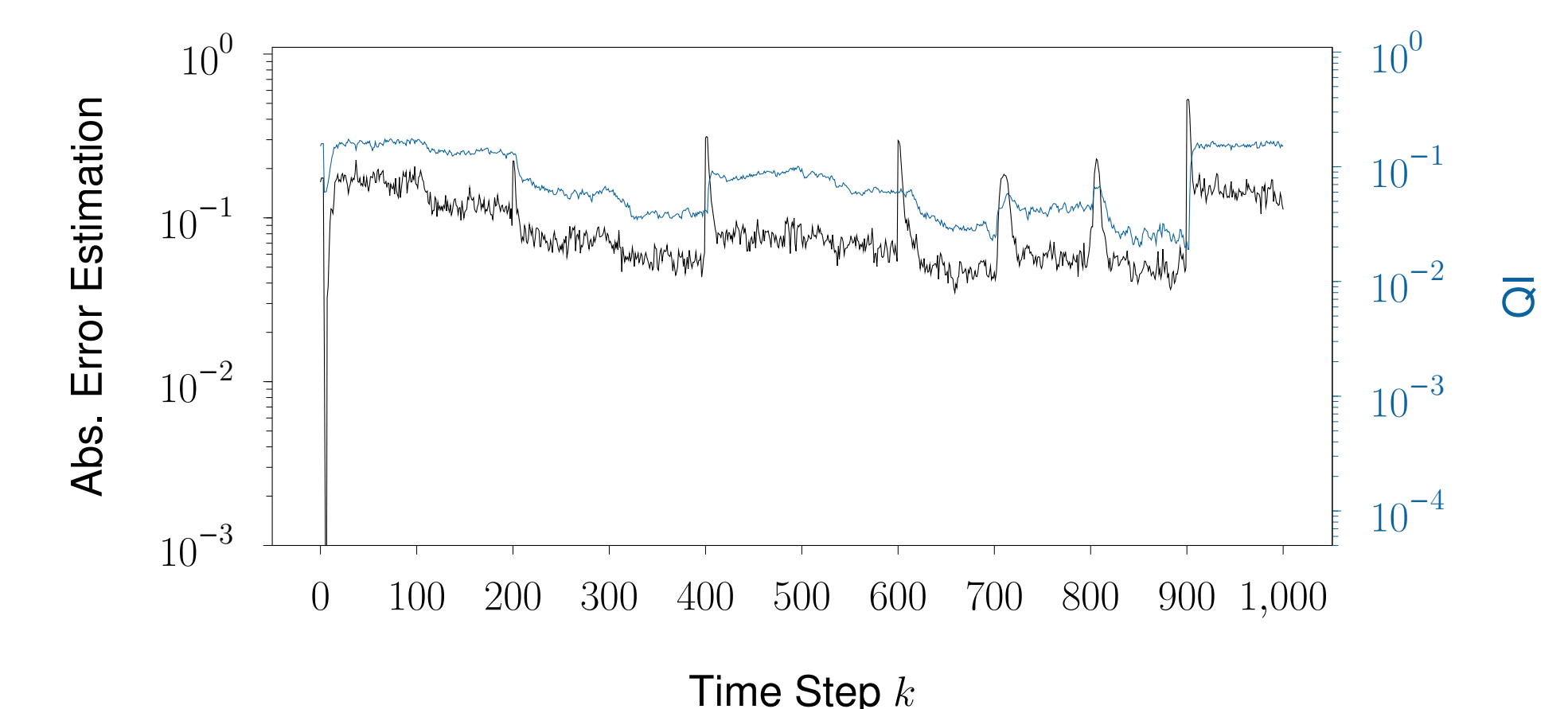
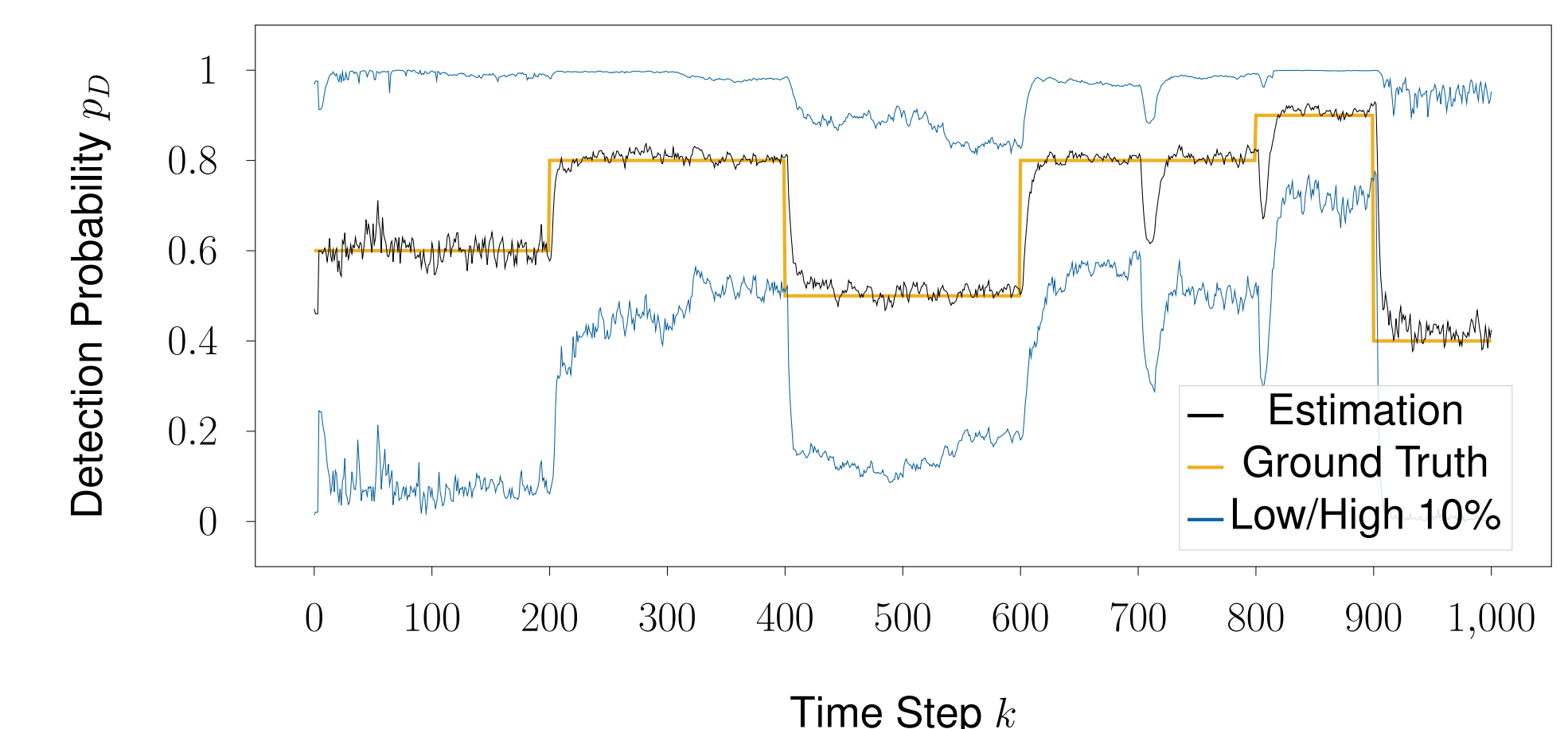
Experimental Setup



Simulation Parameters

- Filter assumes a constant detection probability of 0.8
- Object birth at the black circles
- Constant velocity state model and measurement model (xy-position) with matching noise values

Results



Our proposed method ...

- correctly estimates the detection probability even if the filter uses wrong parameters internally
- detects parameter mismatch and enable adaptive filtering
- guarantees good performance by validating matching parameters

References

- [1] Bundesministerium der Justiz sowie das Bundesamts für Justiz. (2022) Verordnung zur Genehmigung und zum Betrieb von Kraftfahrzeugen mit autonomer Fahrfunktion in festgelegten Betriebsbereichen (Autonome-Fahrzeuge-Genehmigungs- und Betriebs-Verordnung - AFGBV)
- [2] S. Reuter, B.-T. Vo, B.-N. Vo, and K. Dietmayer, "The labeled multi-bernoulli filter," *IEEE Transactions on Signal Processing*, vol. 62, no. 12, pp. 3246–3260.

Contact

All authors are with the
Institute of Measurement, Control and Microtechnology,
Ulm University,
Albert-Einstein-Allee 41, 89081 Ulm, Germany
{firstname}. {lastname}@uni-ulm.de

