Maritime Innovation Update

M. Sc. Emin Nakilcioglu

Advanced Workload Forecasting for Logistic Nodes using Bayesian Networks

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Maritime Innovation Updates, July 2024

Advanced Workload Forecasting for Logistic Nodes Using Bayesian Neural Networks

Emin Nakilcioglu, Fraunhofer CML

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HCS

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Das Startkapital für die Mobilität 4.0

Agenda

The leading applied research organization

1. **KIK-Lee vs. WaProLog**
2. **Day-to-day Workload of a Logistic Node**
   - Use Case “Workload Forecasting for an Empty Container Depot”
3. **Datasets**
4. **Methodology**
   - What has been done
   - What do we offer differently
5. **Forecasting**
   - Performance
   - Achievements and Future Work

Picture: ©HCS Gate Area – IMG_2109.JPG – HCS Hamburger Container Service GmbH

LILIE vs. WaProLog (fka. KIK-Lee)

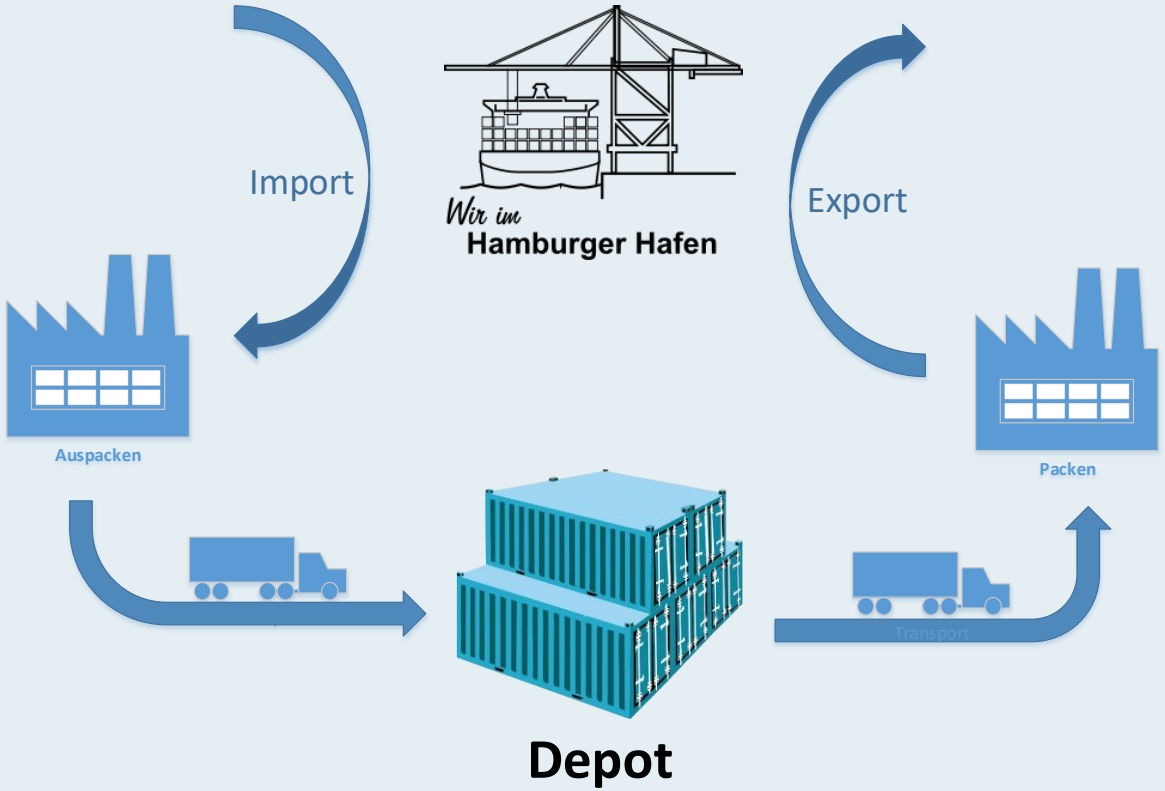
Problem Definition - HCS in the Port of Hamburg

Problem:

- Uncoordinated inflow in the hinterland
- Planning uncertainties on all sides

Solution:

- Optimization using data sharing and AI



Container depots within the workflow of hinterland logistics

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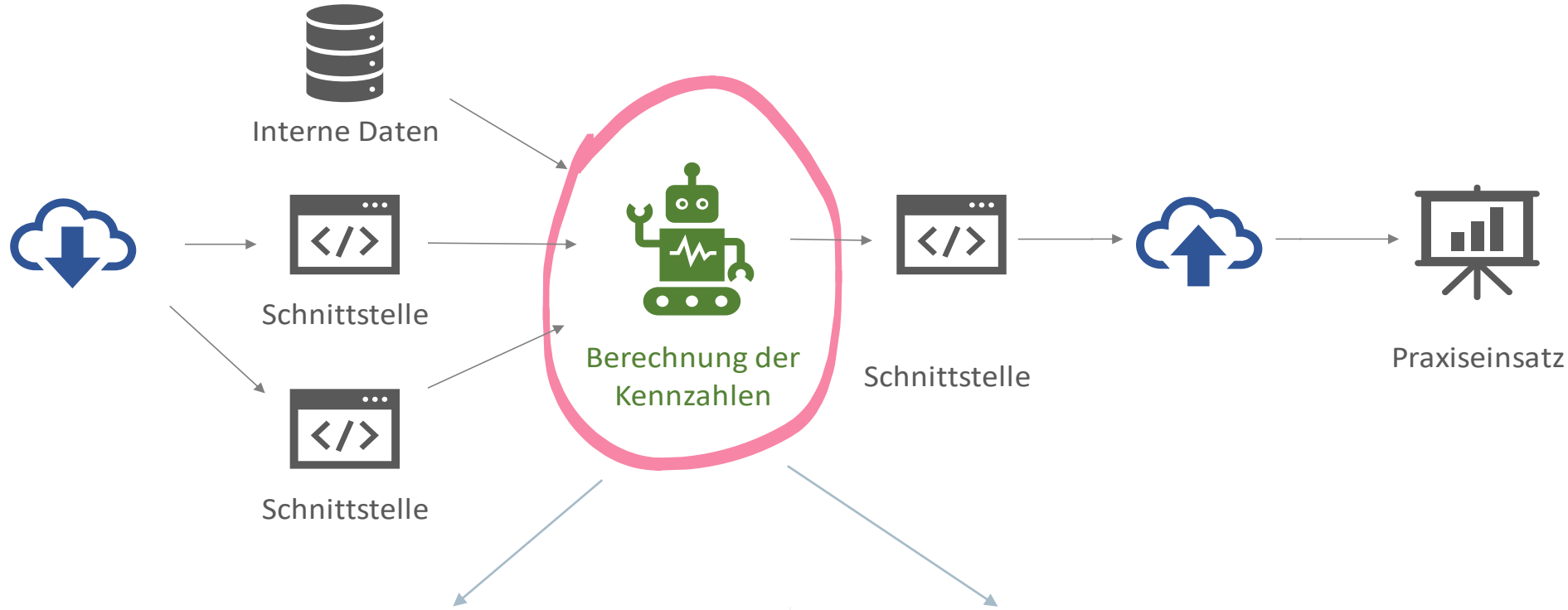
LILIE vs. WaProLog (fka. KIK-Lee)

A Comparative Study with a Follow-up Project

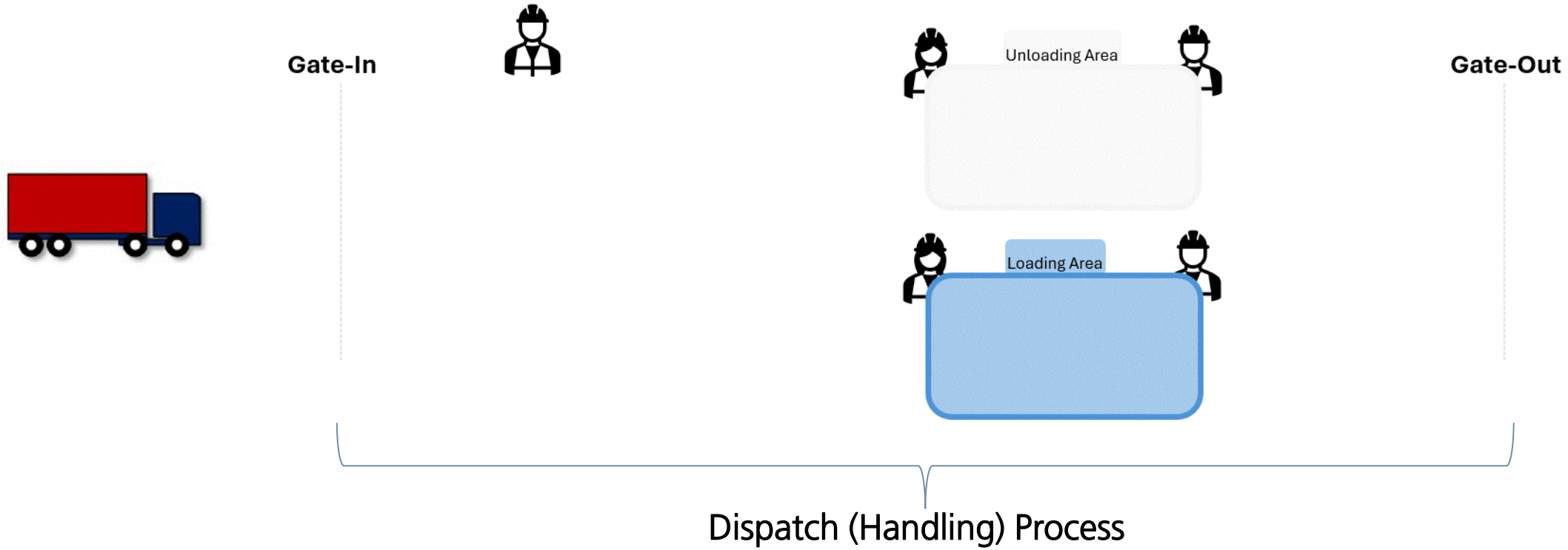


LILIE – Traditional (Deterministic) Approach

WaProLog – Probabilistic Approach

Use Case “Workload Forecasting for an Empty Container Depot”

An Empty Container Depot – Truck Handling Process



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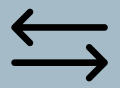
Data

Datasets

Base Data

 Container Type

 Weekday/Holiday

 Load/Unload

 Gate In/Out Time

Additional Data Source

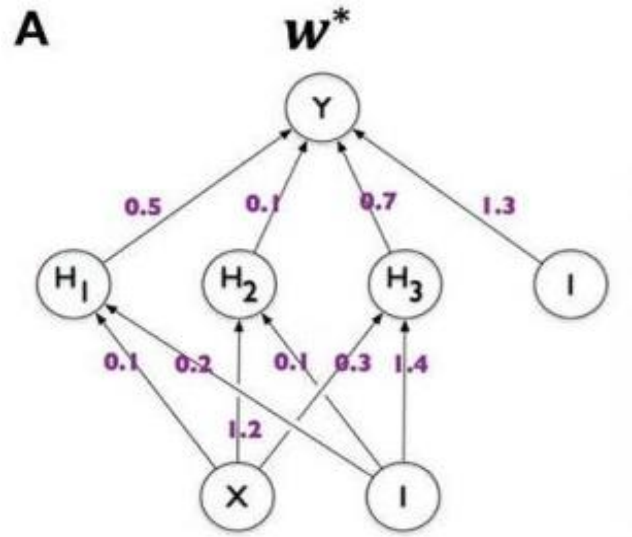
 Trucker Appointment System

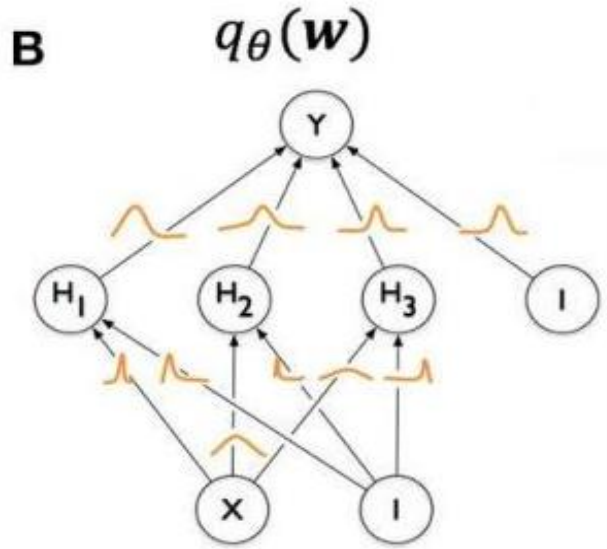
Datasets

- Base Data: consists of data records regarding every container truck that is part of the traffic in the empty container depot in question.
- Trucker Appointment: an appointment system where the truck drivers give their expected arrival time in advance.

Methodology

LILIE vs WaProLog





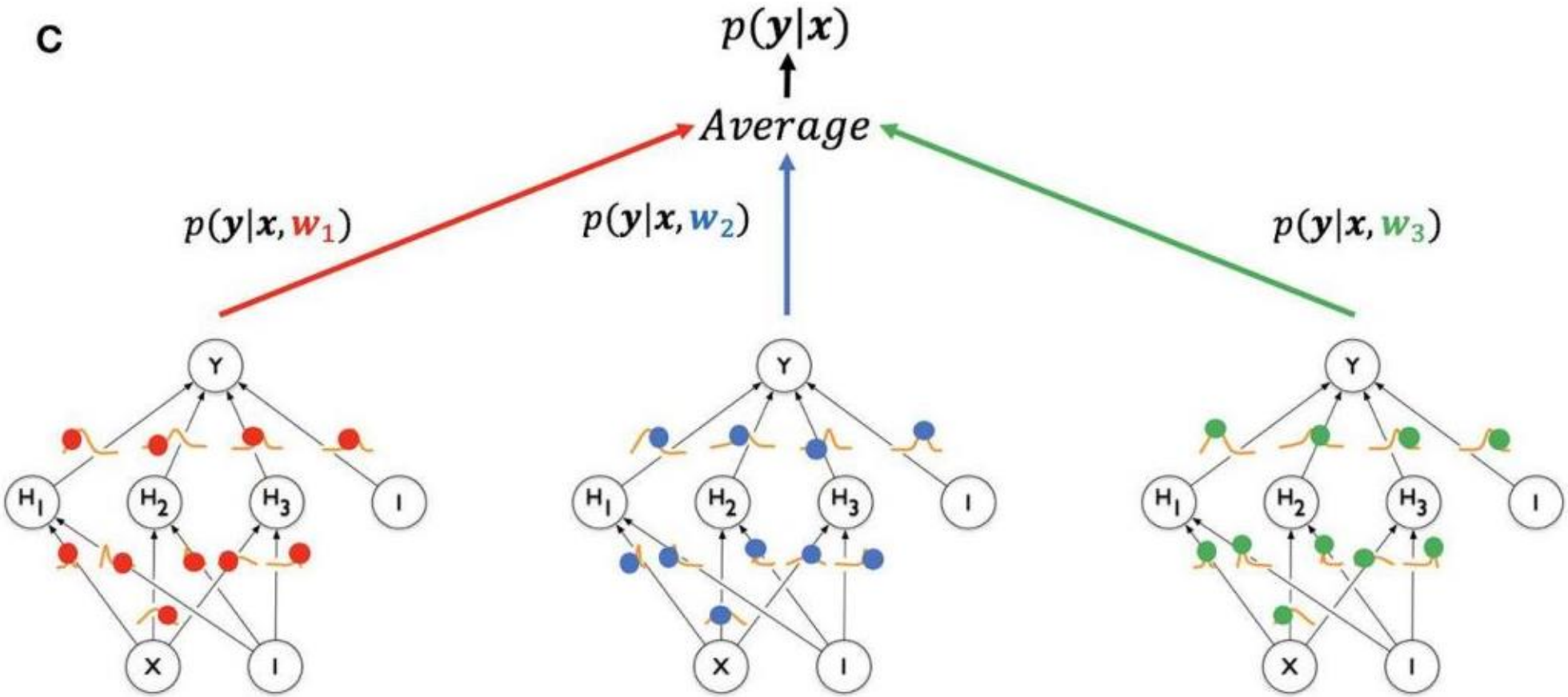
$$p(w|x;y) = \frac{p(y|w;x)\,p(w)}{p(y|x)}$$

LILIE – Traditional (Deterministic) Approach

WaProLog – Probabilistic Approach

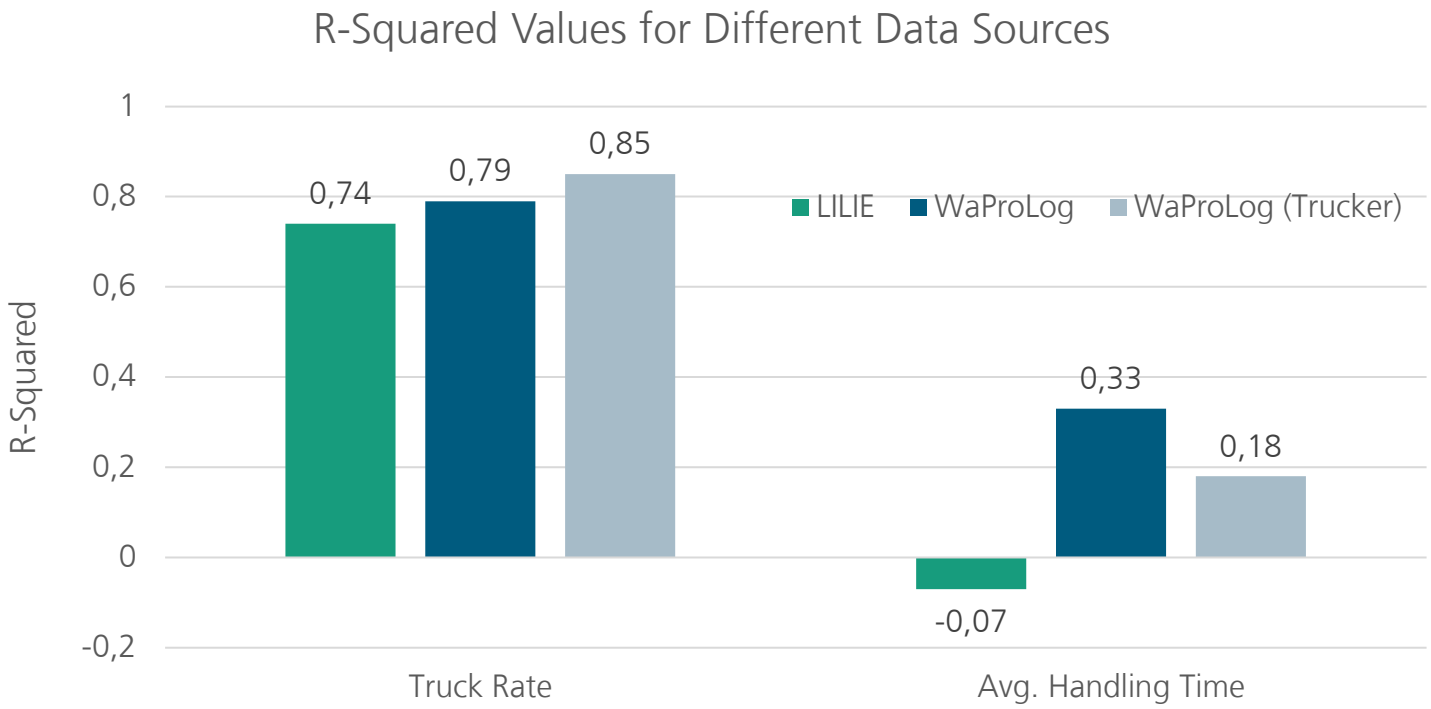
Methodology

Simulation



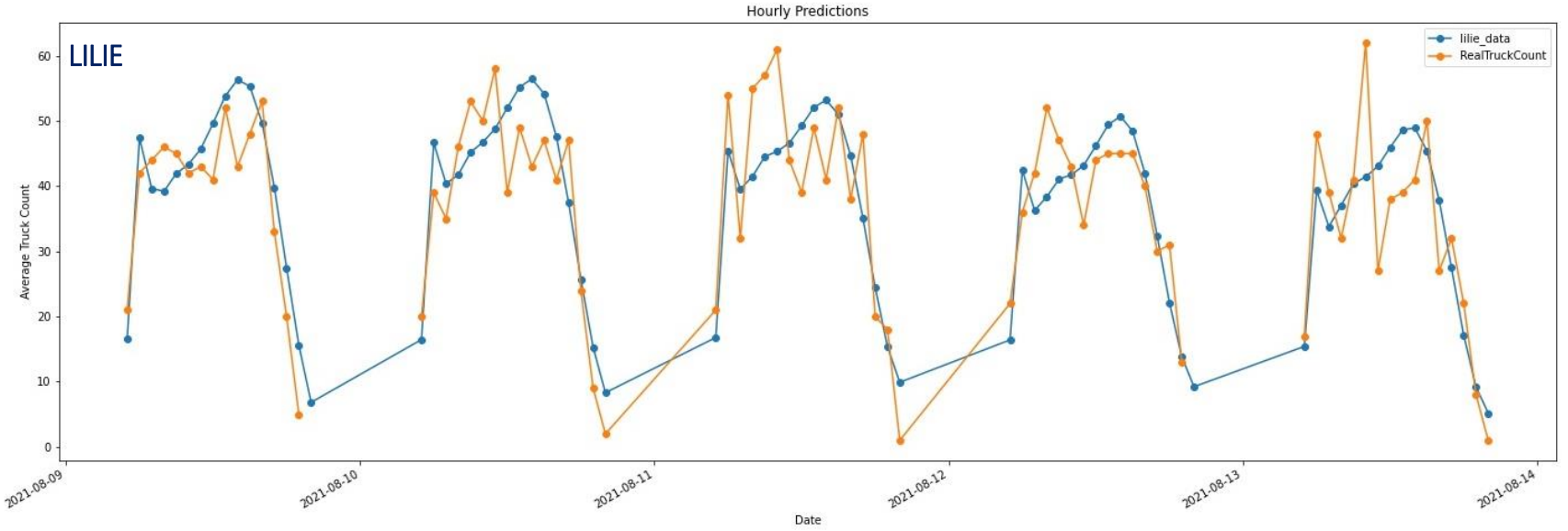
Experimental Results Comparison (Best Performances)

Influence of the different datasets on the Bayesian Model Performance

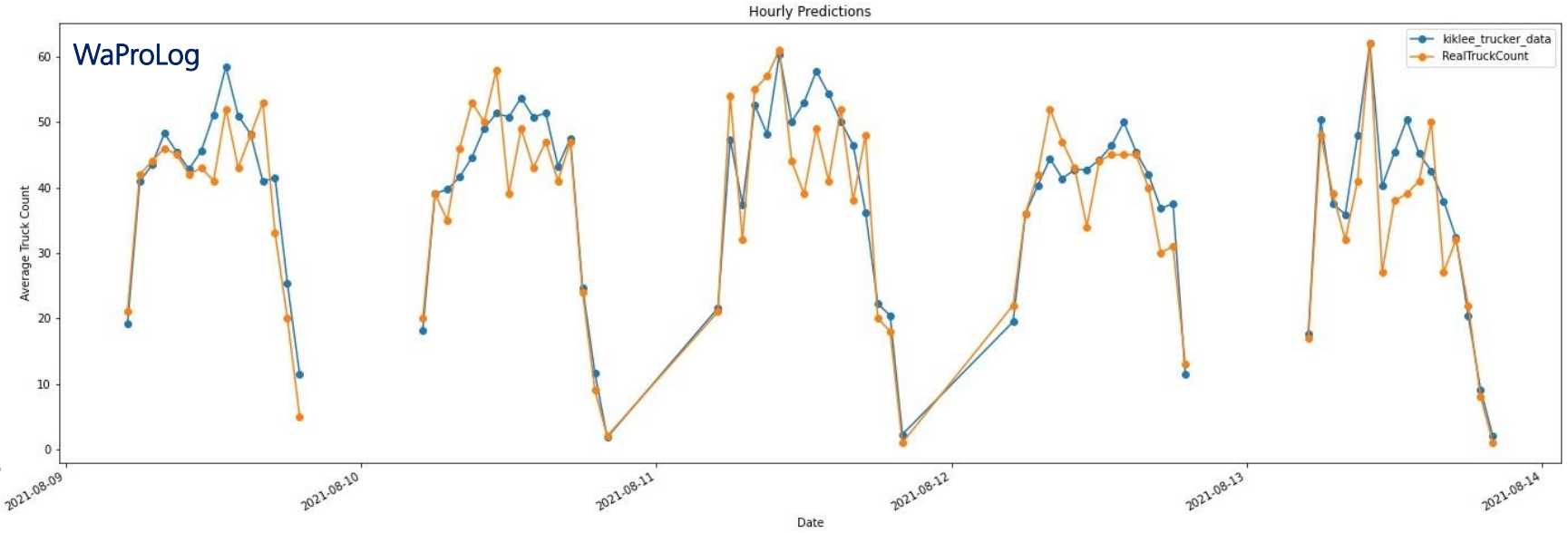


WaProLog	**Overall error rate of ±4,7 trucks for expected truck rate**	**Overall error rate of ±6,7 min for average truck dispatch time (**
LILIE	**Overall error rate of ±6,4 trucks for expected truck rate**	**Overall error rate of ±7,6 min for average truck dispatch time**

Experimental Results Comparison (Best Performances)



Overall error rate of ±6,4 trucks for expected truck rate



Overall error rate of ±4,7 trucks for expected truck rate

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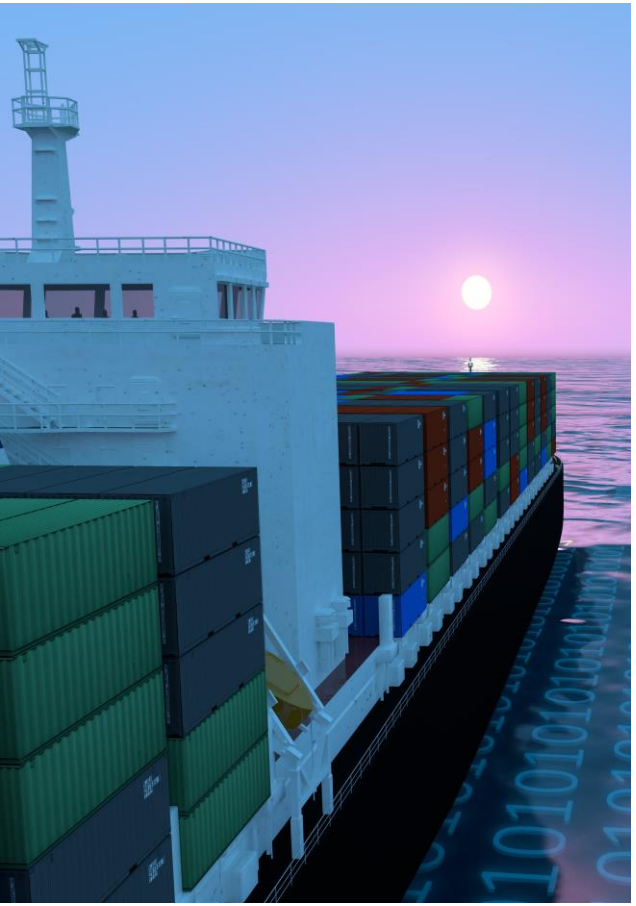
Achievements and Future Aspects



1

- **The proposed BNN (i.e. predictor)** is capable of forecasting the hourly workload in an empty container depot for upcoming weeks **more efficiently and more stable** than the previously developed **DNN-based model**.

2

- **~6,7% increase** in performance of hourly predictions of expected truck rate
  - Additional ~**15% increase** by using trucker booking system
- **~103% performance increase** in hourly predictions of average truck handling time
- **Faster predictions (~52%)** with less computational power (went down **from 20 min to 7 min**)

3

- Extracting more relevant information from the current data sources (**CAx, Sailing List** etc.) and introducing new relevant datasets,
- Capturing both the **epistemic and the aleatoric uncertainty** together in a further research.

4

- **Further development** work of the forecasting model
- **Automatizing the process** of publishing the forecast result.

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Maritime Innovation Update

MIU continues in September 2024

We wish you a wonderful summer!

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