An approach to Fleet monitoring perspective

Ikerlan MOIRA Workshop June 2024

Fleet Definition

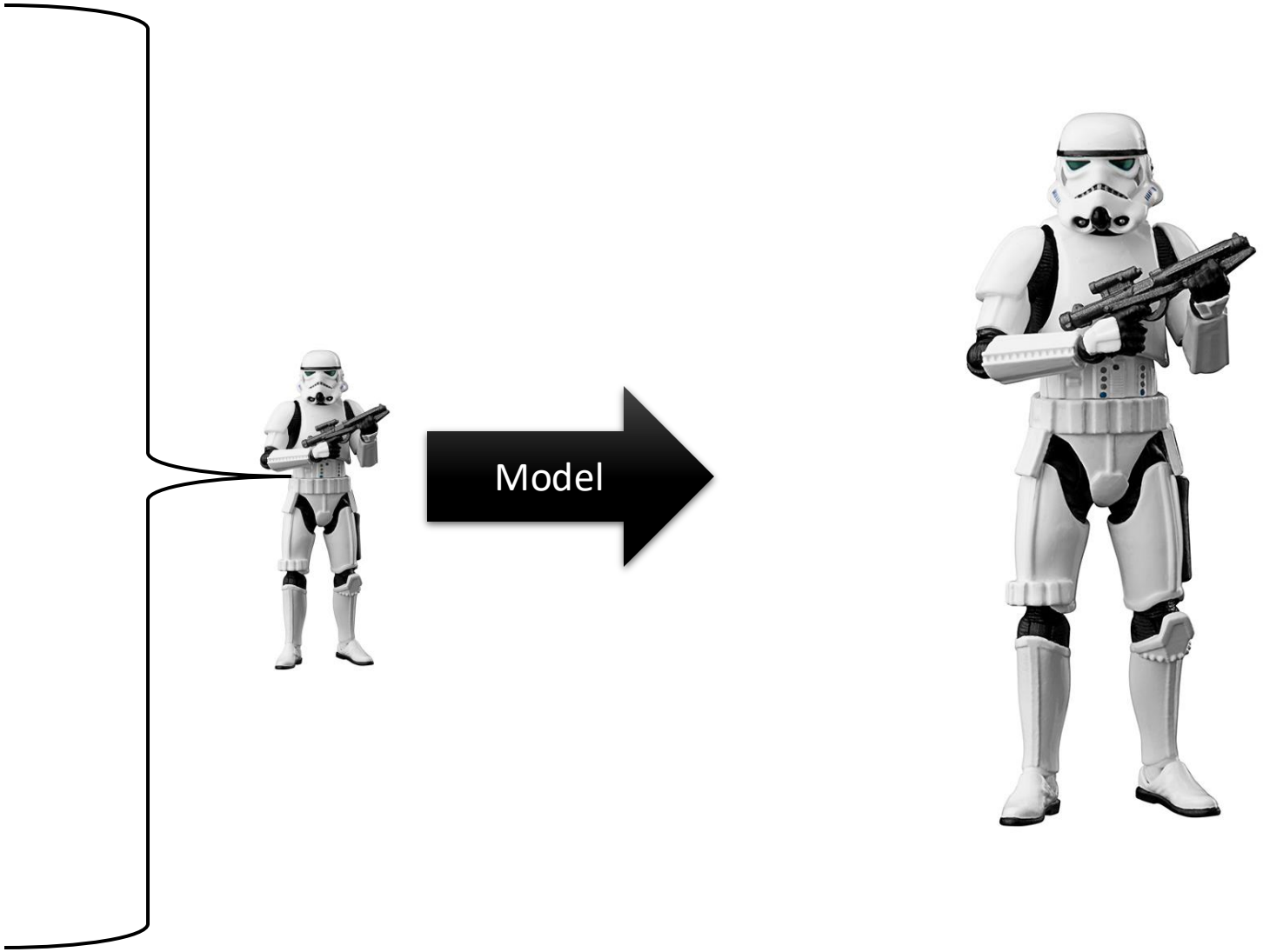
Fleet Monitoring Approaches

Probabilistic Denity Function explained

GPR

Conclusion

Fleet Definition



Fleet Definition

Fleet Monitoring Approaches

Probabilistic Density Function explained

GPR

Conclusion

Fleet Monitoring Approaches

- **Fleet-Based Condition Monitoring:**
  - Focuses on monitoring the condition of a specific vehicle or machine within the fleet.
  - Emphasizes monitoring each unit of the fleet separately.
  - Includes monitoring the condition of components such as the engine, tires, brakes, and other specific elements of a vehicle.
  - Centralized **approach to individual units.**
- **Fleet-Wide Condition Monitoring:**
  - Involves comprehensive monitoring of the entire fleet as a whole.
  - Concentrates on combining data from all vehicles or machines in the fleet.
  - Aims to provide an overall picture of the condition and performance of the entire fleet.
  - Takes a **holistic approach** to fleet-wide analysis.

Fleet Monitoring Approaches

- **Fleet-Based Condition Monitoring:**
  - Focuses on monitoring the condition of a specific vehicle or machine within the fleet.
  - Emphasizes monitoring each unit of the fleet separately.
  - Includes monitoring the condition of components such as the engine, tires, brakes, and other specific elements of a vehicle.
  - Centralized **approach to individual units.**
- **Fleet-Wide Condition Monitoring:**
  - Involves comprehensive monitoring of the entire fleet as a whole.
  - Concentrates on combining data from all vehicles or machines in the fleet.
  - Aims to provide an overall picture of the condition and performance of the entire fleet.
  - Takes a **holistic approach** to fleet-wide analysis.

Fleet Monitoring Approaches

- **Fleet-**
  - Ba

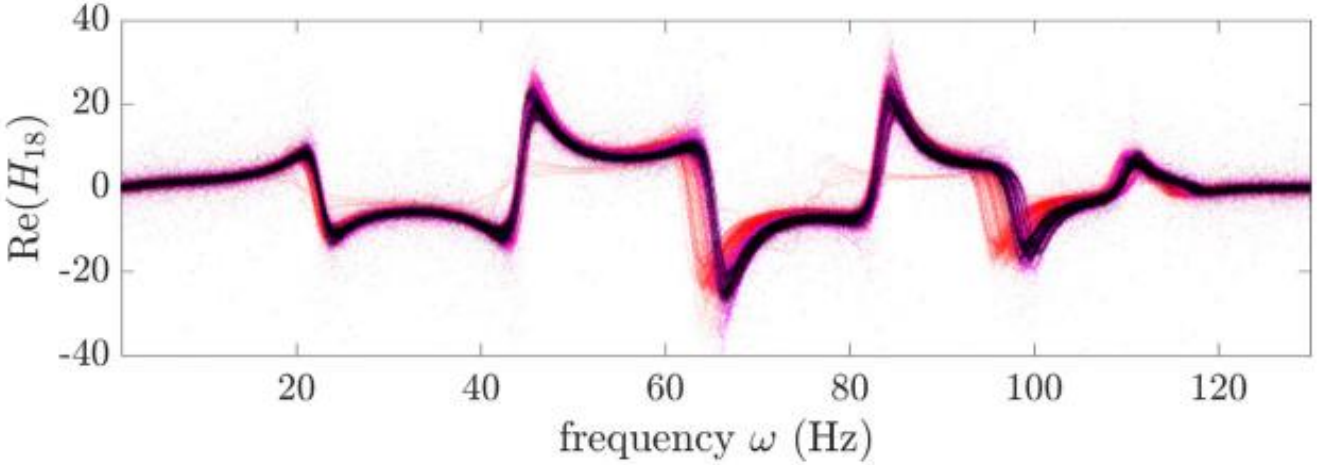
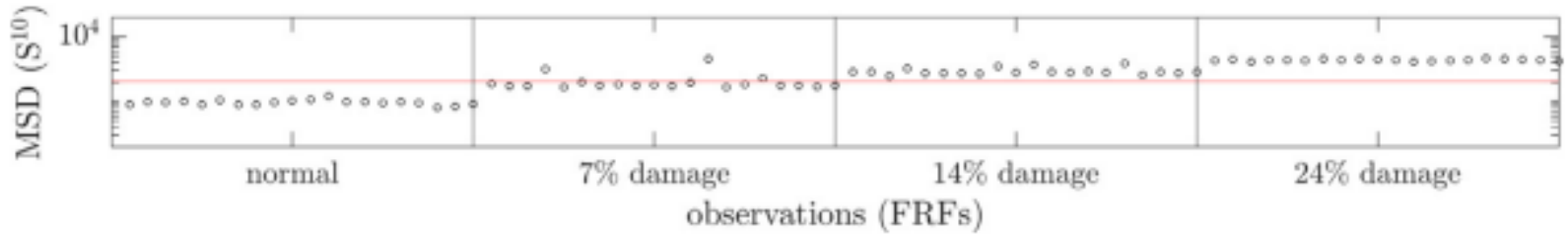


Fig. 3. FRFs data from a population of twenty 8DOF systems $\{S_1, \ldots, S_{20}\}$. $S_{1:19}$ are simulated members and S_{20} the experimental rig. The normal-condition is shown by black markers (training-data) and magenta markers (test-data), while the damage data are shown by red markers (test-data).



Bull, L. A., Gardner, P. A., Gosliga, J., Rogers, T. J., Dervilis, N., Cross, E. J., ... & Worden, K. (2021). Foundations of population-based SHM, Part I: Homogeneous populations and forms. Mechanical Systems and Signal Processing, 148, 107141.

Fleet Definition

Fleet Monitoring Approaches

Probabilistic Density Function explained

GPR

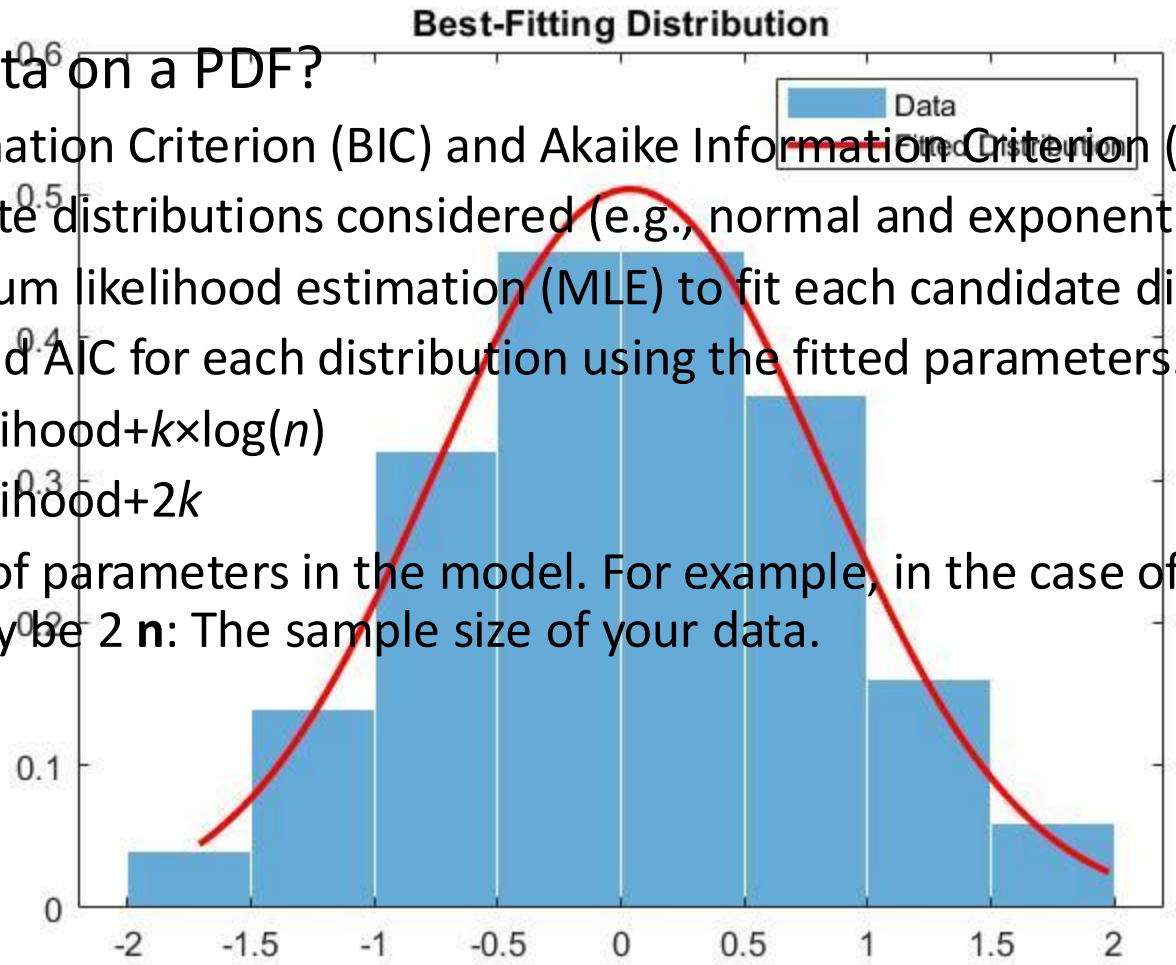
Conclusion

Probabilistic Density Function explained

- **Probabilistic Process:**
  - Applied to a normal distribution, it displays probabilities associated with different values.
  - Helps understand the range and likelihood of potential outcomes in a given scenario.
- **Probabilistic Density Function (PDF):**
  - PDF visually represents the likelihood of outcomes for a random variable.
  - The curve illustrates the probabilities linked to various values of the random variable.
- **Stochastic Process:**
  - As the PDF evolves over time or space, it becomes a stochastic process.
  - Each realization of the process is unique, and the PDF captures probabilities at different moments or locations.

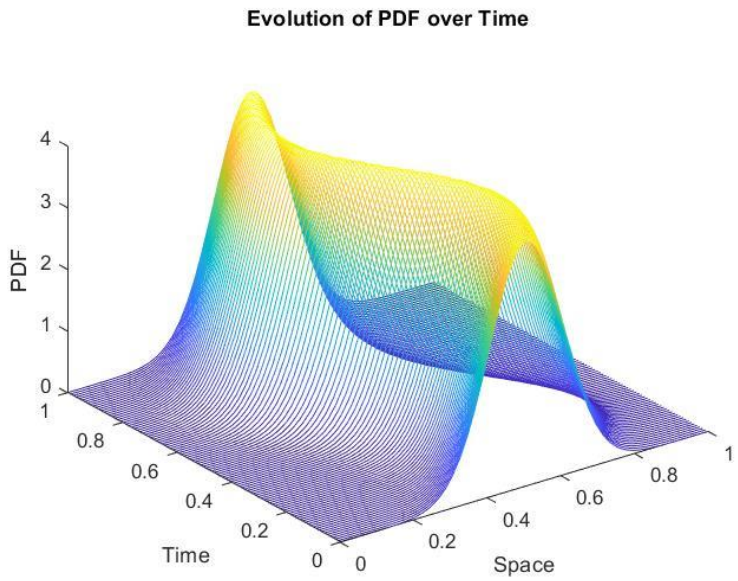
Probabilistic Density Function explained

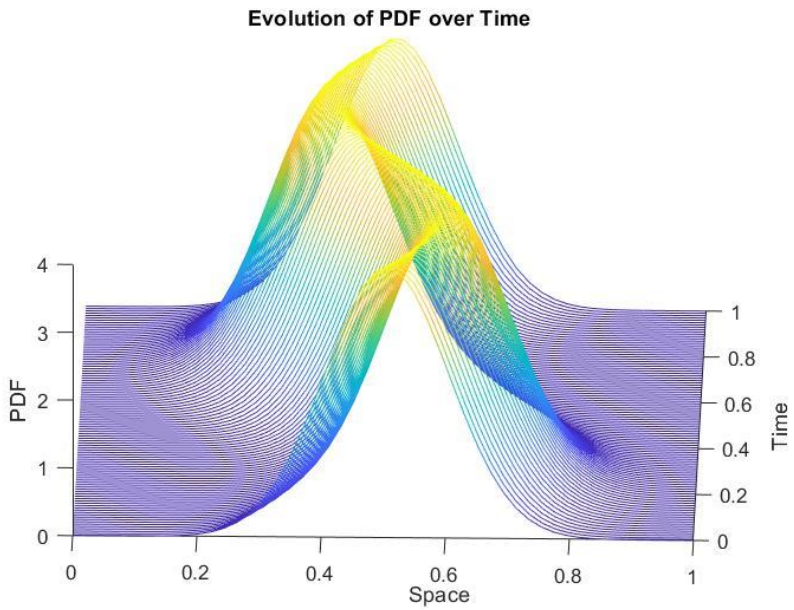
- How do we fit data on a PDF?
  - Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC)
  - List the candidate distributions considered (e.g., normal and exponential)
  - Using of maximum likelihood estimation (MLE) to fit each candidate distribution to the data.
  - Compute BIC and AIC for each distribution using the fitted parameters.
  - BIC=−2×log likelihood+k×log(n)
  - AIC=−2×log likelihood+2k
  - **k**: The number of parameters in the model. For example, in the case of a normal distribution, **k** would typically be 2 **n**: The sample size of your data.

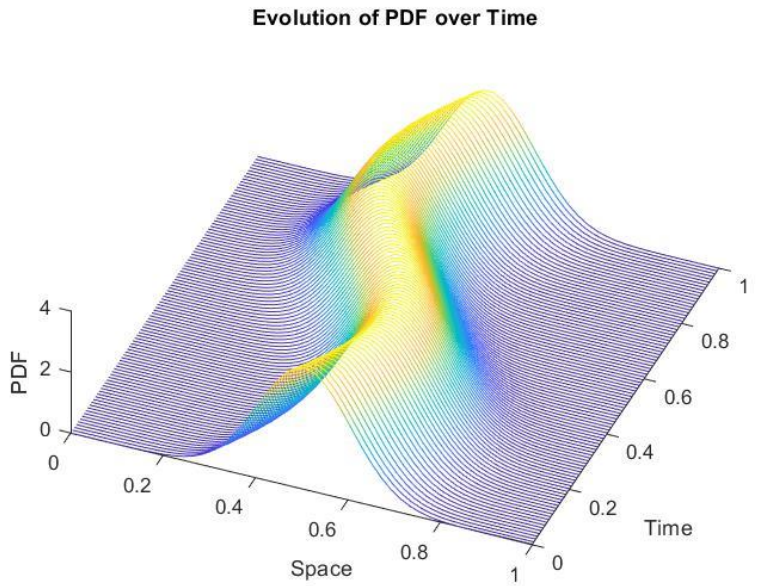


Probabilistic Density Function explained

- **How to create the Stochastic Process of a Mechanism**
  - As the PDF evolves over time or space, it becomes a stochastic process.

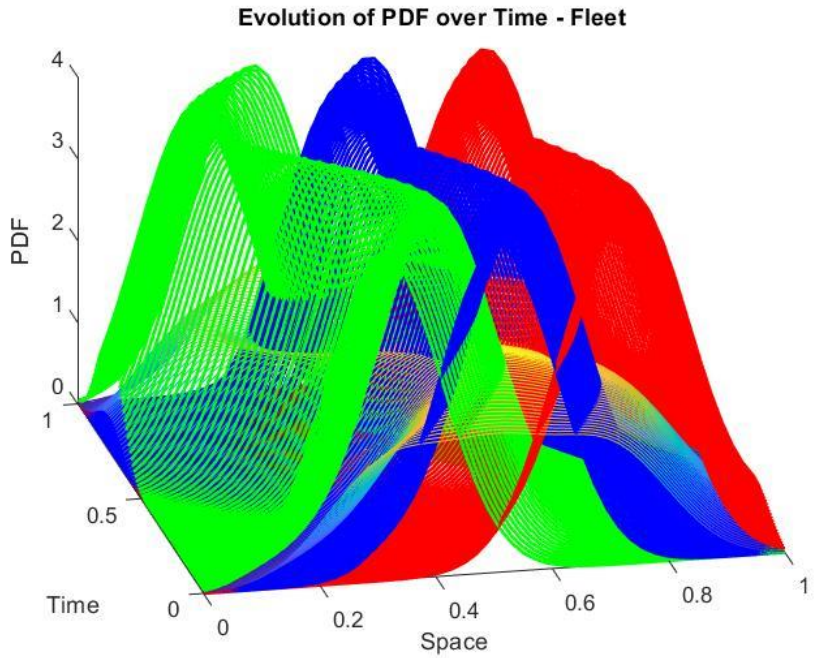






Probabilistic Density Function explained

- **How to create the Stochastic Process of a Fleet**
  - As the PDF evolves over time and **machines**, it becomes a stochastic process.



- How to combine:
  - Weighted combination
  - Product combination
  - Maximum combination
  - Minimum combination
  - Non linear combination

Fleet Definition

Fleet Monitoring Approaches

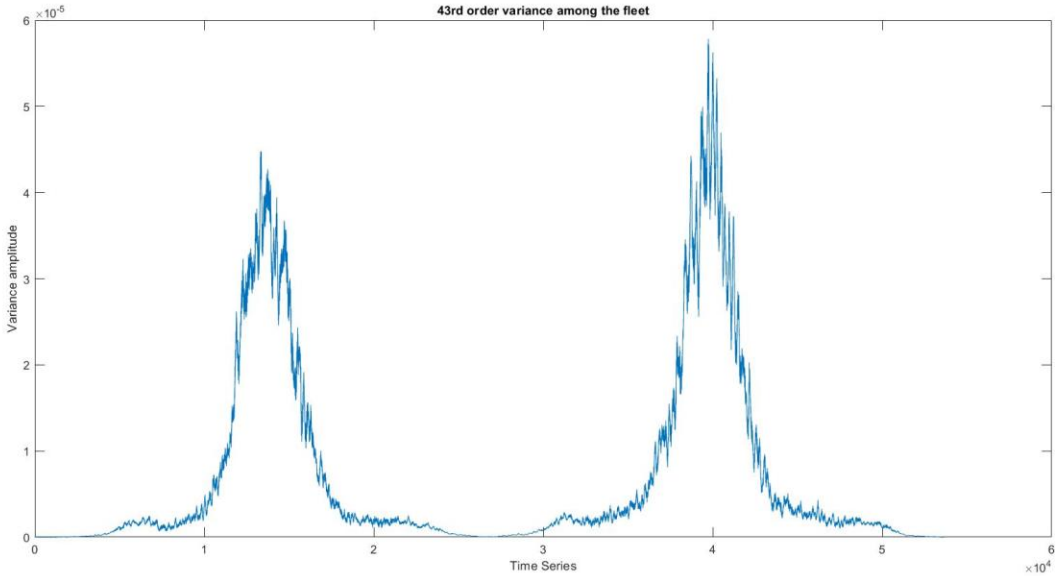
Probabilistic Density Function explained

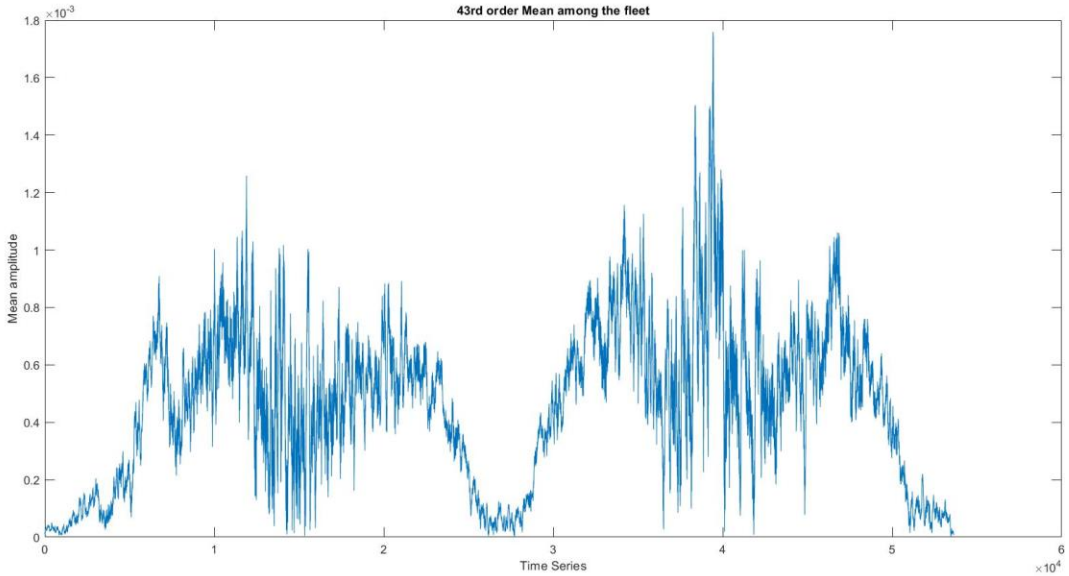
GPR

Conclusion

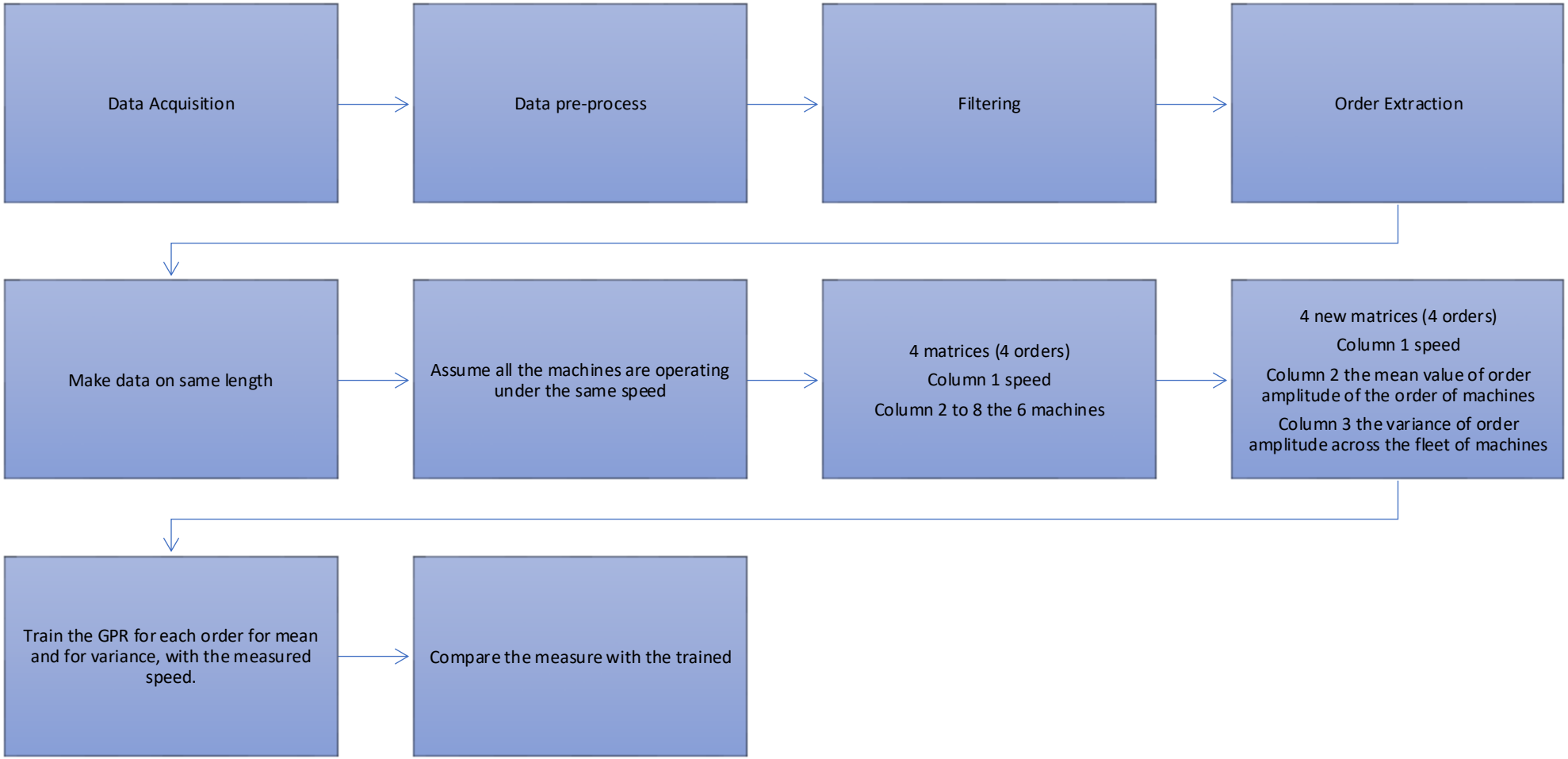
Mean & Variance Amplitude

- Mean is a trend among the fleet
- Data do not follow a specific distribution so to estimate the variance. Variance is depending on the speed

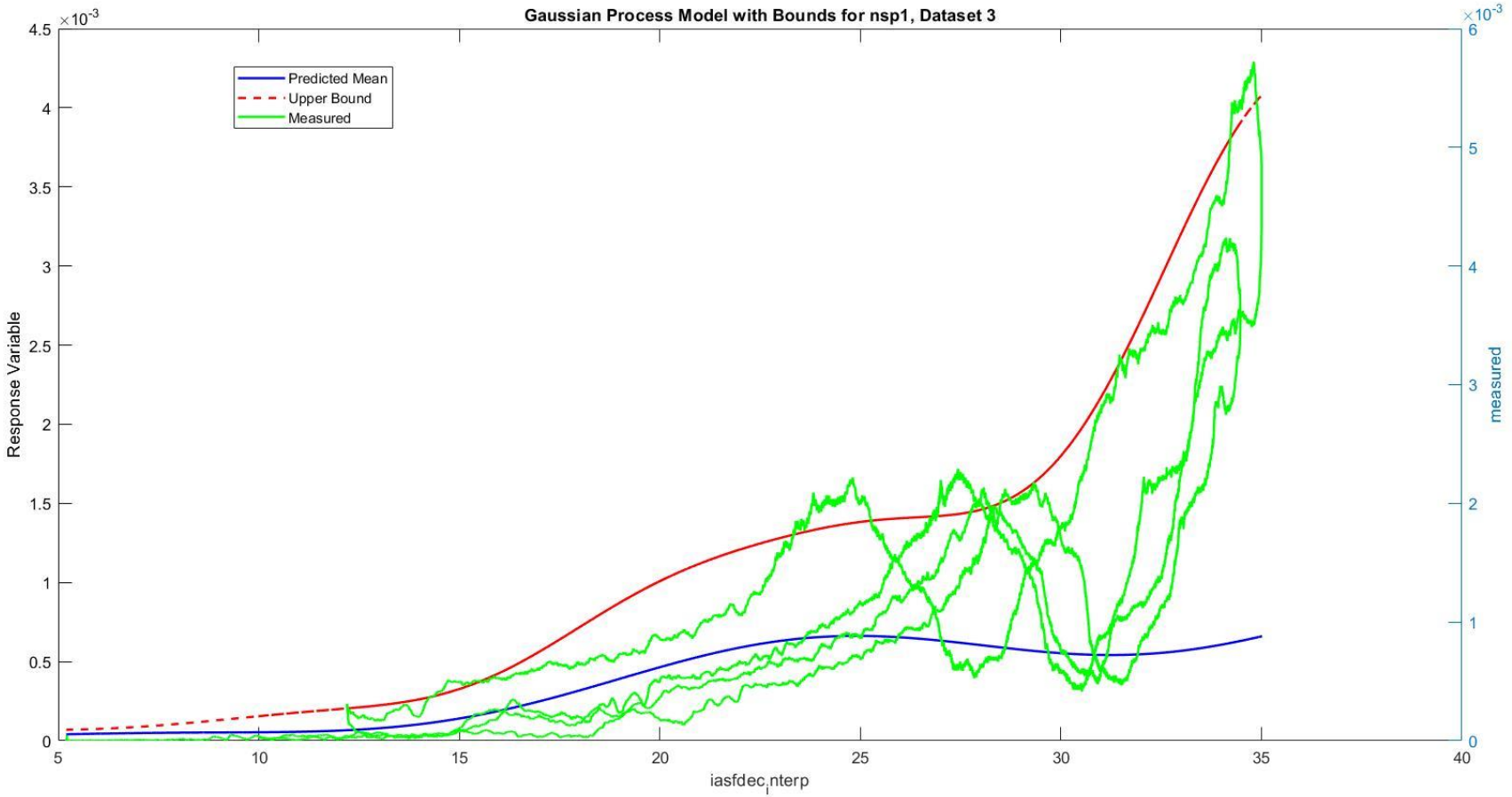




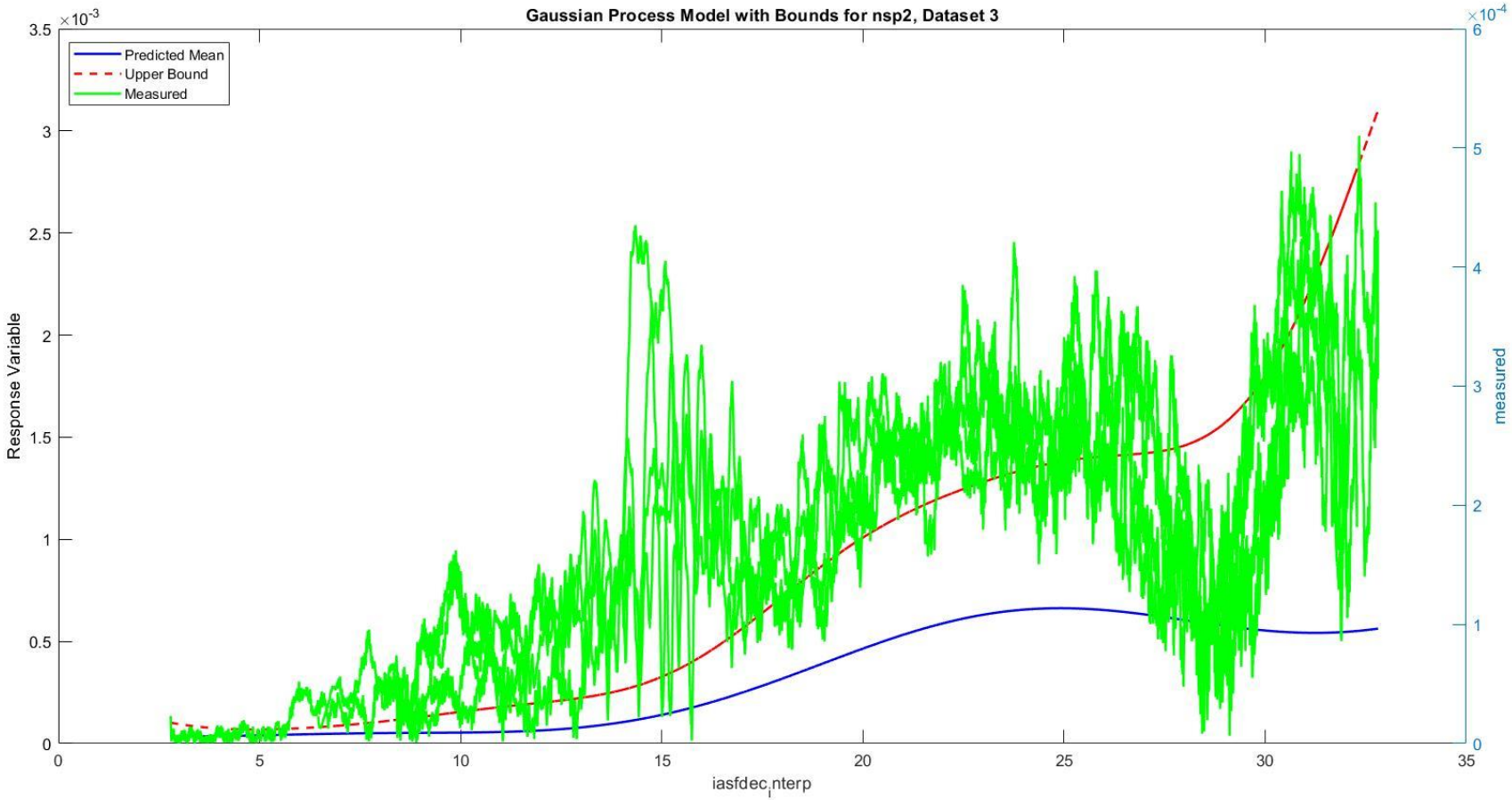
GPR

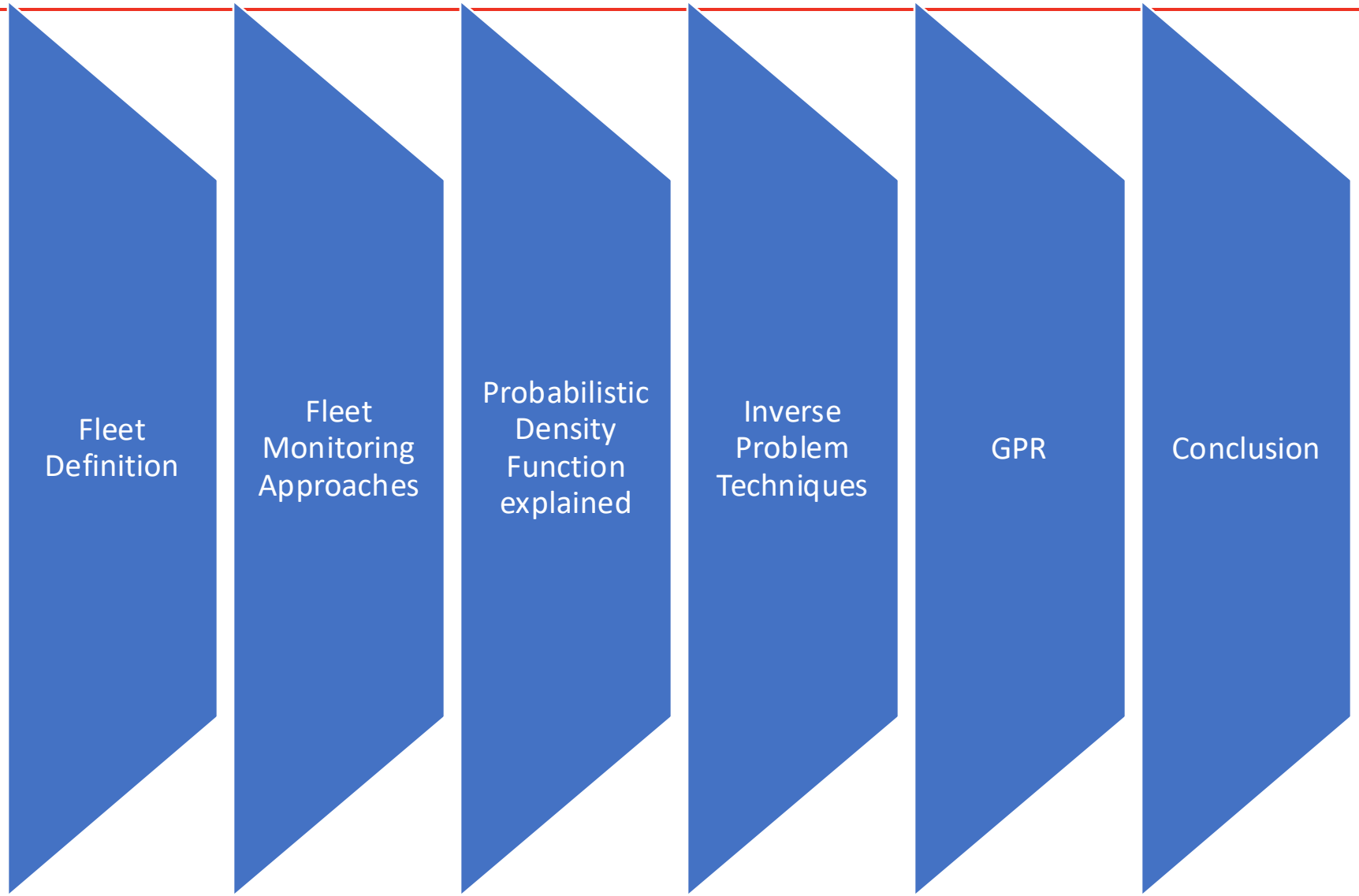

Data Acquisition
Data pre-process
Filtering
Order Extraction
Make data on same length
Assume all the machines are operating under the same speed
4 matrices (4 orders)
Column 1 speed
Column 2 to 8 the 6 machines
4 new matrices (4 orders)
Column 1 speed
Column 2 the mean value of order amplitude of the order of machines
Column 3 the variance of order amplitude across the fleet of machines
Train the GPR for each order for mean and for variance, with the measured speed.
Compare the measure with the trained

GPR


Gaussian Process Model with Bounds for nsp1, Dataset 3
Predicted Mean
Upper Bound
Measured
Response Variable
measured
iasfdec_interp
×10^-3

GPR


Gaussian Process Model with Bounds for nsp2, Dataset 3
Predicted Mean
Upper Bound
Measured
Response Variable
measured
iasfdec_interp
×10^-3
×10^-4


Fleet Definition
Fleet Monitoring Approaches
Probabilistic Density Function explained
Inverse Problem Techniques
GPR
Conclusion

Conclusion

- Improvements/Changes
  - MCMC for speed estimation
  - Try to solve and implement the inverse problem idea
  - Maybe CNN on estimating speed

Thank you!
Merci!
Grazie!
Gracias!
Dziękuję!
متشكرم!
Ευχαριστώ!(Efcharisto!)
Bedankt!
Xièxiè nǐ!
***धन्यवाद!**(dhanyavaad!)*

The authors gratefully acknowledge the European Commission for its support of the Marie Skłodowska Curie program through the ETN MOIRA project (GA 955681)