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Capturing Variability in Material Property Predictions for Plastics Recycling via Machine Learning

Marcin Pietrasik and Anna Wilbik (DACS)
Sin Yong Teng and Kim Ragaert (CCE)

Maastricht University

Proud partners
Sitech Services
TNO
Maastricht University
Brightlands Chemelot campus

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Background

- Mechanical recycling of plastic waste is the **most prominent method** within the circular economy
- The recycling process involves the creation of new plastic blends from recycled monomaterials
    - The properties of mixed plastic blends do not linearly resemble those of their individual pure components

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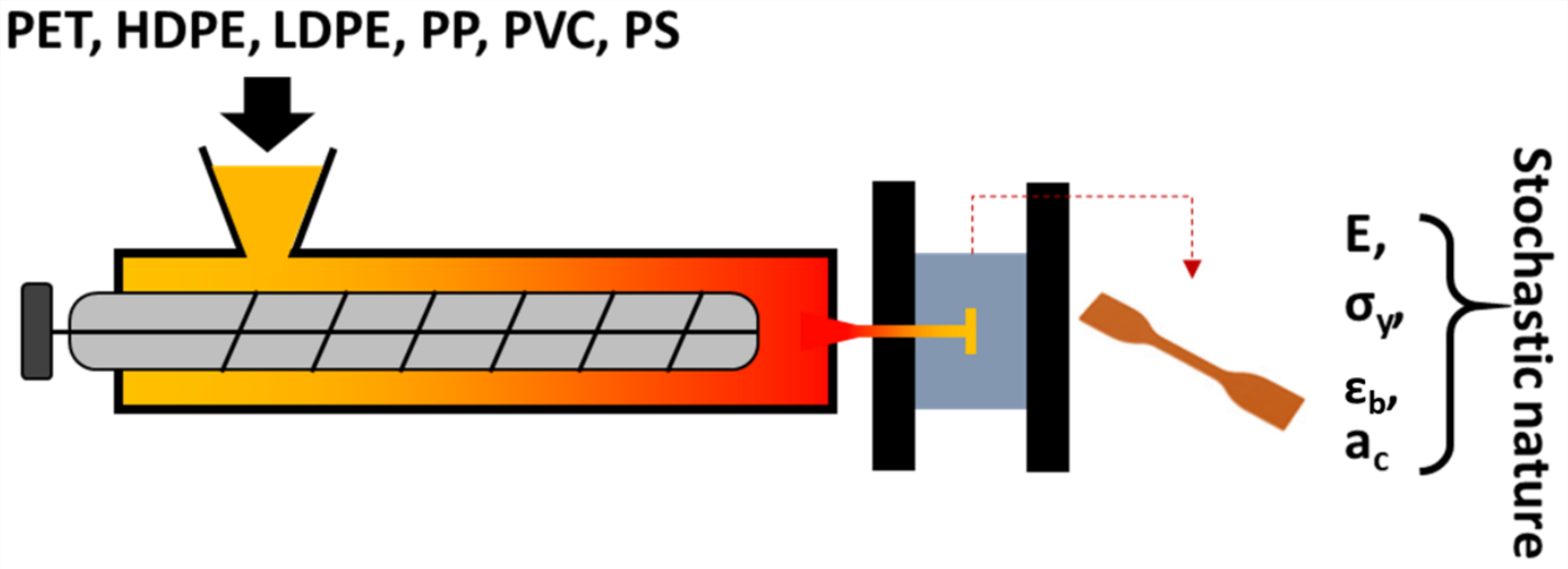
Motivation

- Challenges arise in plastics recycling from nonlinear rules of mixture and **uncertainty in measurement**
- Need for **improved modelling** of recycled plastic properties with uncertainty



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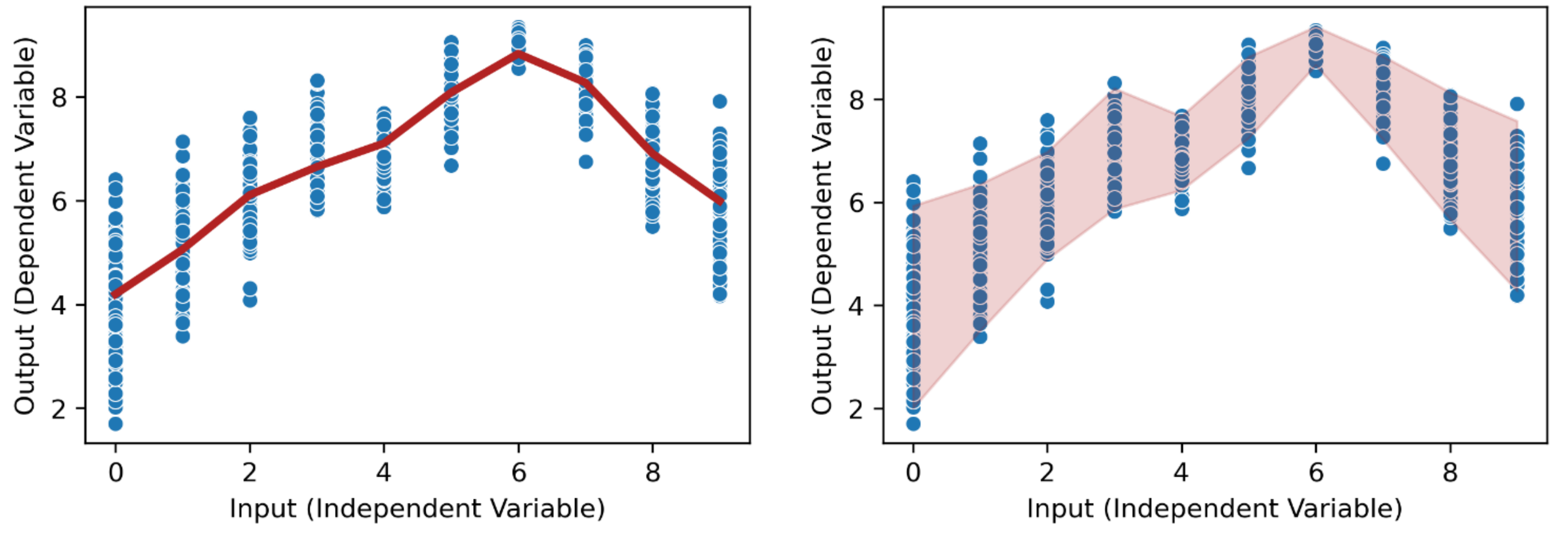
Proposed Solution

- Data-driven model leveraging **machine learning** can be used to predict physical properties of plastics given their composition
- We propose a framework consisting of **regression models** and **prediction interval methods** for capturing variability of plastic properties



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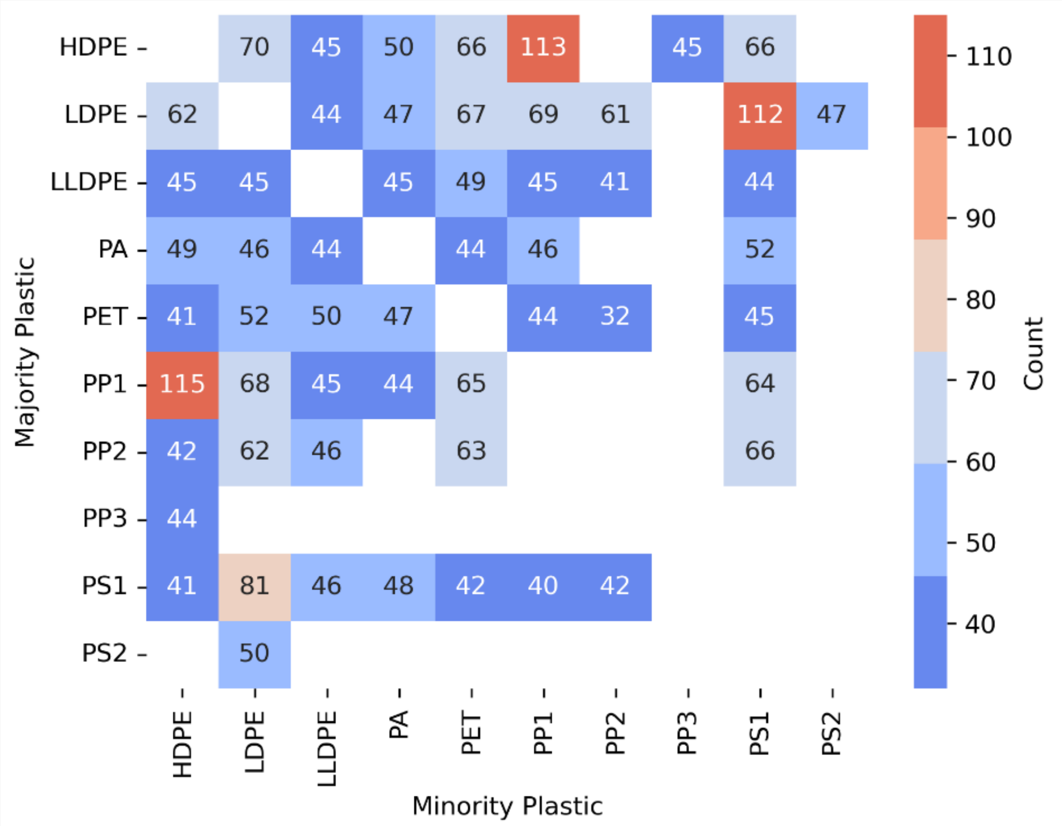
Data

- We obtained a custom data of 3646 plastic blend observations composed of 10 monomaterials
- Properties measured:
    - Elastic modulus (*E*)
    - Yield strength (*σy*)
    - Strain at break (*εb*)
    - Impact strength (*ac*)



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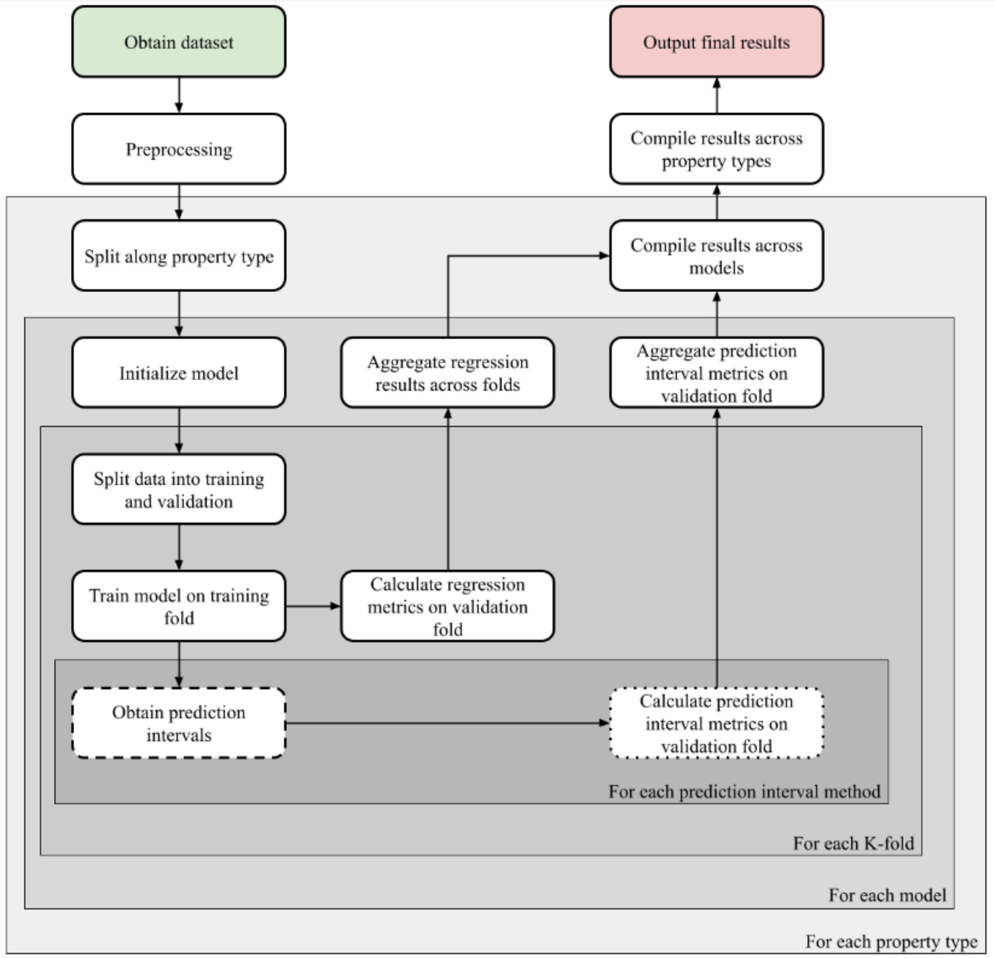
Methodology

- **Regression models:** Ridge, Lasso, Decision Tree, SVR, GBR, Gaussian Process
- **Interval prediction methods:** Residuals based, Bootstrapping, Conformal
- **Evaluation** using RMSE, R^2, coverage, interval width.



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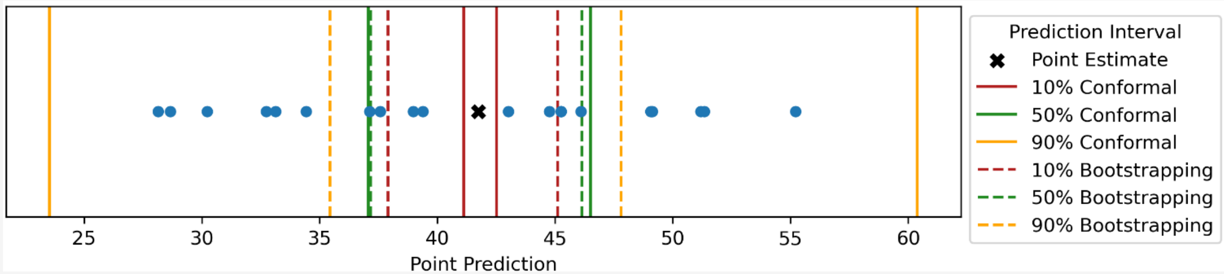
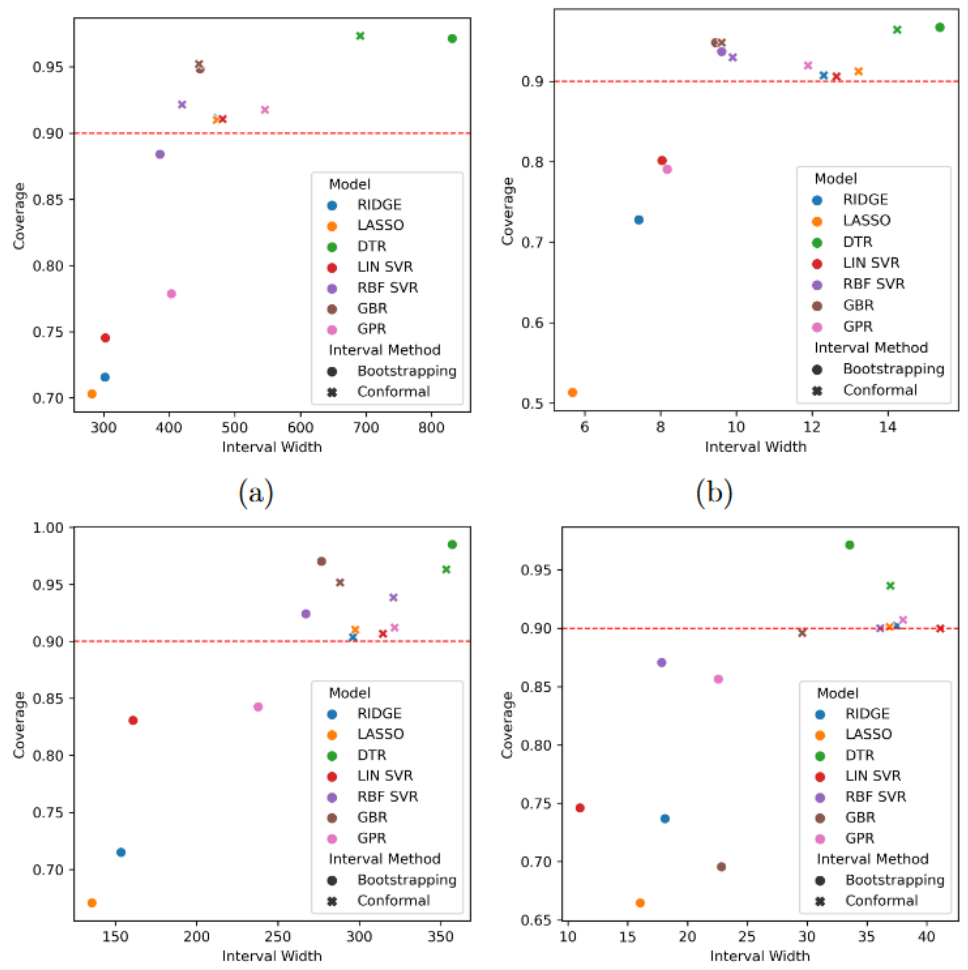
Results

- **Best point estimators:** GBR and RBF SVR performed best overall
- **Best interval methods:** conformal prediction outperformed bootstrapping





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Conclusions

- Interval ML effectively models property variability in plastic blends
- GBR and Conformal prediction recommended for practical applications
- Future work:
  - Unified models optimizing both prediction accuracy and interval precision
  - Integration of more diverse data sources and advanced models (e.g., deep learning)