MAPIE

Uncertainty quantification

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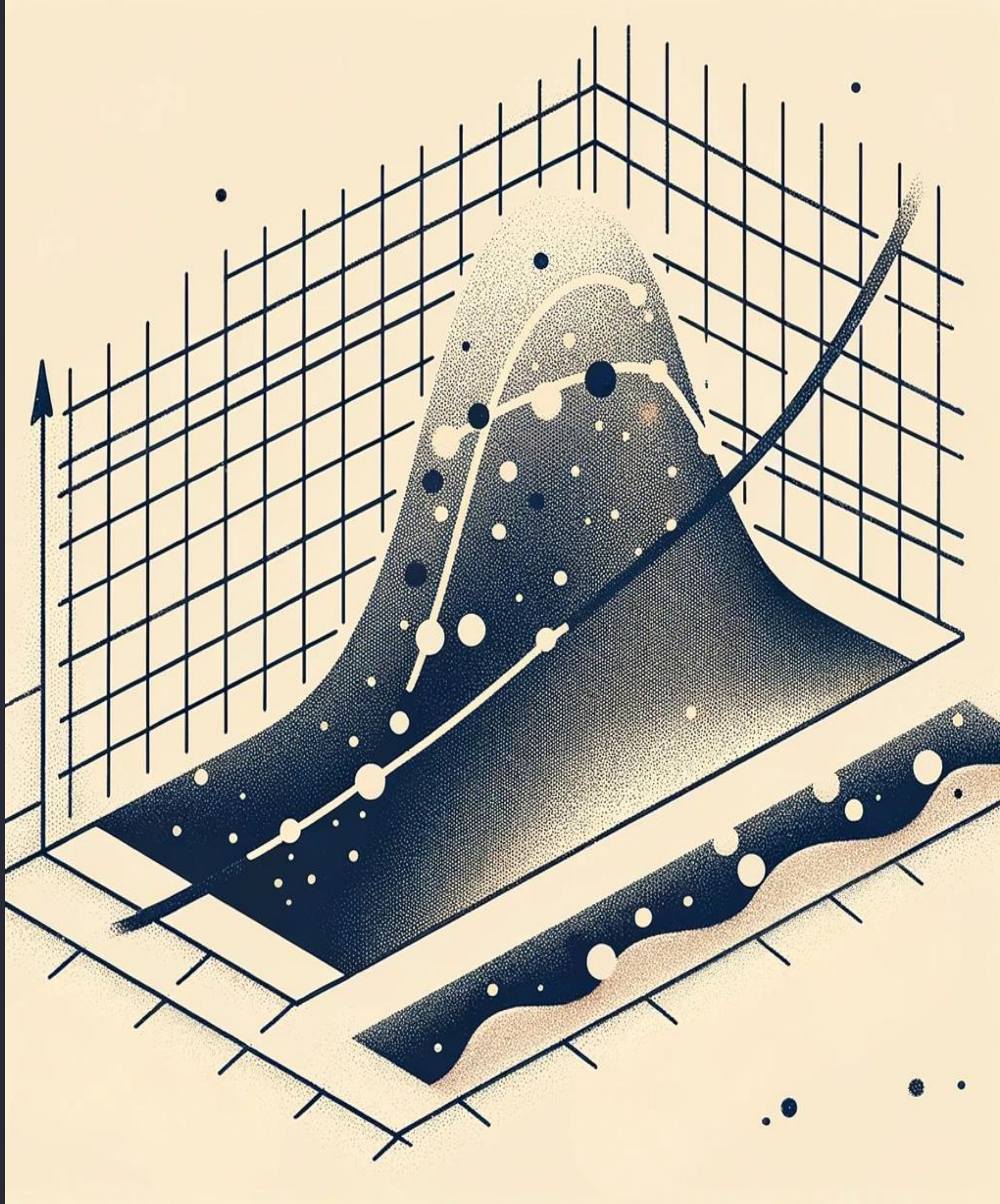
Communs numériques
pour une IA souveraine



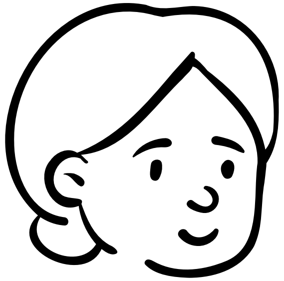
Uncertainty quantification with MAPIE

1. Why quantifying uncertainty?
2. Introducing MAPIE
3. What's next?
4. Q&A

Why quantifying uncertainty?

Because wrong expectations lead to wrong decisions…

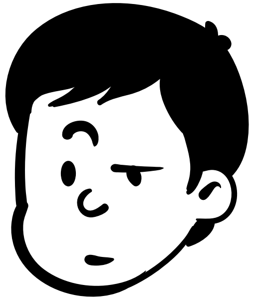
Model



I predict this is
gonna be OK

Business

Just how sure
were you, again?



Uncertainty quantification: methods

Conformal prediction is the only method that does not require distribution assumption and provides coverage guarantee.

Family of Methods	Method	Description	Advantages	Disadvantages
Resampling Methods	Bootstrap Jackknife Cross-validation	Use resampling techniques to estimate the uncertainty of model predictions	- Simple to implement - Efficiently uses available data	- Can be computationally expensive
Bayesian Methods	Bayesian Inference	Incorporates prior knowledge and updates it with data to estimate model parameters	- Incorporates uncertainty into the model - Allows incremental updates	- Can be complex to implement - Can be computationally expensive
	Monte Carlo Dropout Concrete Dropout	Applies dropout during training and testing to estimate prediction uncertainty	- Simple to implement - More computationally efficient	- May require hyperparameter tuning - Poorly approximates complex posterior
Uncertainty Quantification Methods	Uncertainty Propagation	Propagates input uncertainties through the model to estimate output uncertainties	- Allows propagation of uncertainty - Provides a complete estimate of uncertainty	- Can be complex to implement - Can be computationally expensive
	Confidence Interval	Provides prediction intervals within which the true value is likely to fall	- Simple to interpret - Provides an estimate of uncertainty	- Depends on distribution assumptions
	Quantile Regression	Models the conditional quantiles of the response variable	- Allows modelling of distribution quantiles - Useful for heteroscedastic data	- Does not provide coverage guarantees - May require specific adjustments
	Calibration	Adjusts the model's predictions to better match the true probabilities	- Simple to interpret - Allows correction of biases	- Depends on how the probabilities are discretised, only for classification
	Conformal Prediction	Provides prediction intervals within which the true value is likely to fall, with guaranteed coverage and without distribution assumptions	- Simple to implement - **Provides coverage guarantees** - **Does not require distribution assumptions** - **Only require exchangeability data assumption** - **Is model and use case agnostic**	- Can be conservative - May require specific adjustments to deal with heteroscedasticity

How to explain conformal prediction to your grandmother?

Regression task: age estimation

Model prediction: 24

MAPIE prediction interval: [20, 29]
(with 90% confidence)

Classification task: species identification

Model prediction: zebra

MAPIE prediction set: {zebra, horse}
(with 90% confidence)

MAPIE

Model Agnostic Prediction Interval Estimator

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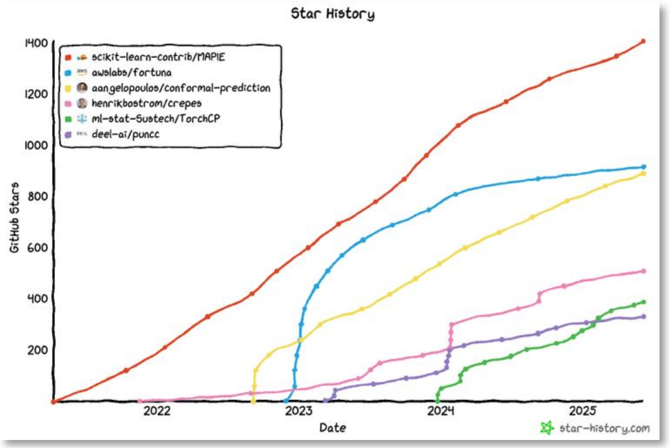
MAPIE – your go-to package for uncertainty quantification

What is MAPIE?

MAPIE is an uncertainty quantification package to control the risks associated with AI models.

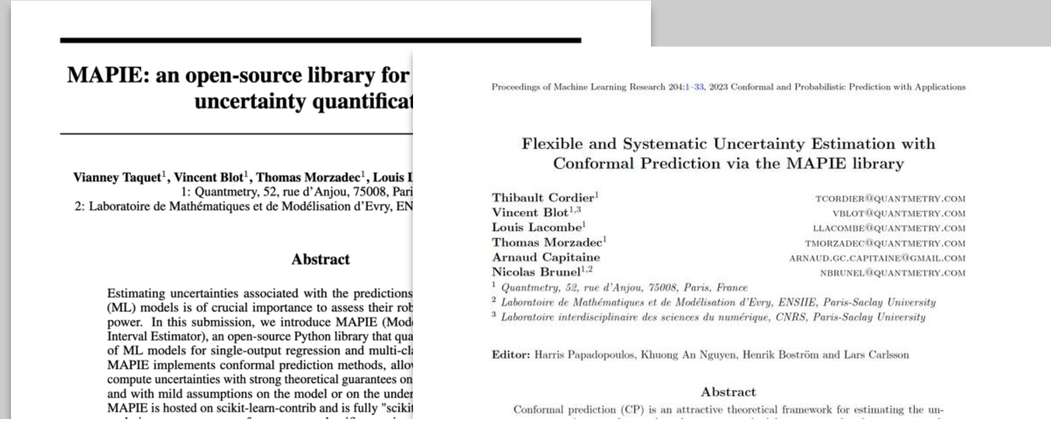
- Python package
- Open source
- Comprehensive documentation
- State-of-the-art mathematical guarantees
- Integrated into the scikit-learn ecosystem



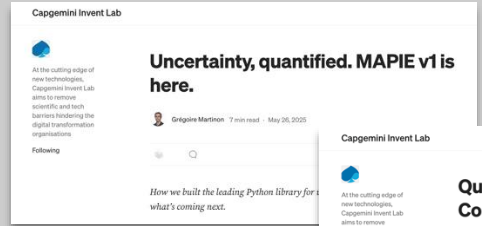
Multiple facets of MAPIE

Documentation

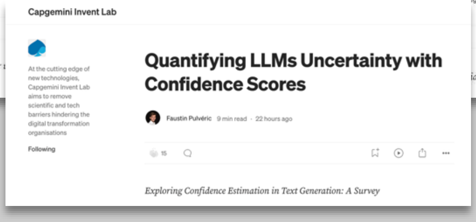
Scientific publications



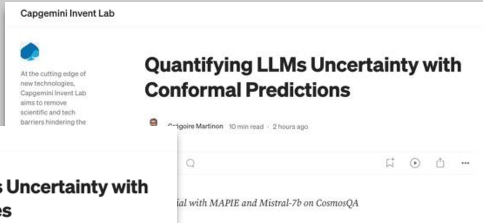
Blog articles



https://medium.com/capgemini-invent-lab/uncertainty-quantified-mapie-v1-is-here-b0d0f953b5ac



https://medium.com/capgemini-invent-lab/quantifying-llms-uncertainty-with-confidence-scores-6bb8a6712aa0



https://medium.com/capgemini-invent-lab/quantifying-llms-uncertainty-with-conformal-predictions-567870e63e00

ANY data science problem? MAPIE is here to help

MAPIE
1.0.1
Search docs

GETTING STARTED
- Quick Start with MAPIE
- The conformalization (or "calibration") set
- Choosing the right algorithm
- MAPIE v1 release notes

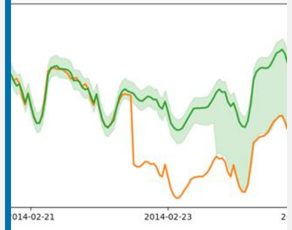
MEASURE PREDICTIONS UNCERTAINTY
- Prediction intervals (regression)
- Prediction sets (classification)

CONTROL PREDICTION ERRORS
- Theoretical Description
- Tutorial for recall and precision control for multi-label classification
- Risk control notebooks

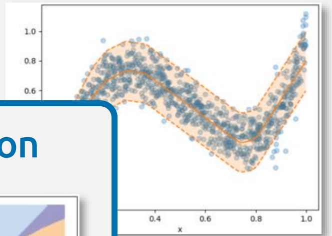
CALIBRATE MULTI-CLASS PREDICTIONS
- Theoretical Description
- Calibration examples
- Calibration notebooks

QUESTION & ANSWERS
- Metrics: how to measure conformal prediction performance?
- Mondrian: how to use prior knowledge on groups when measuring uncertainty?

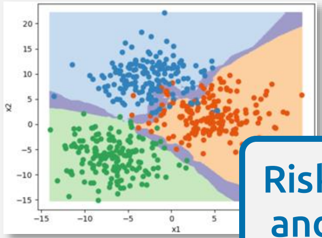
Time Series



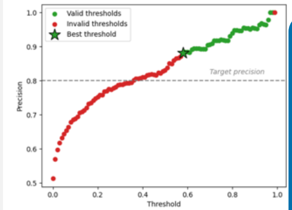
Regression



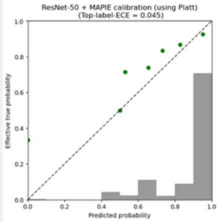
Classification



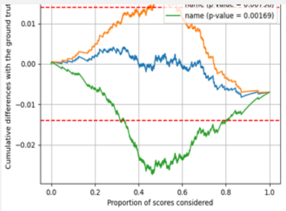
Risk Control (binary and segmentation)



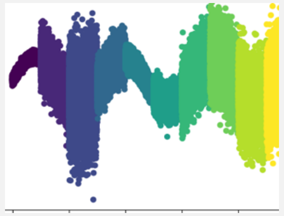
Calibration



Calibration Testing



Groupwise uncertainty



LLM Risk Control

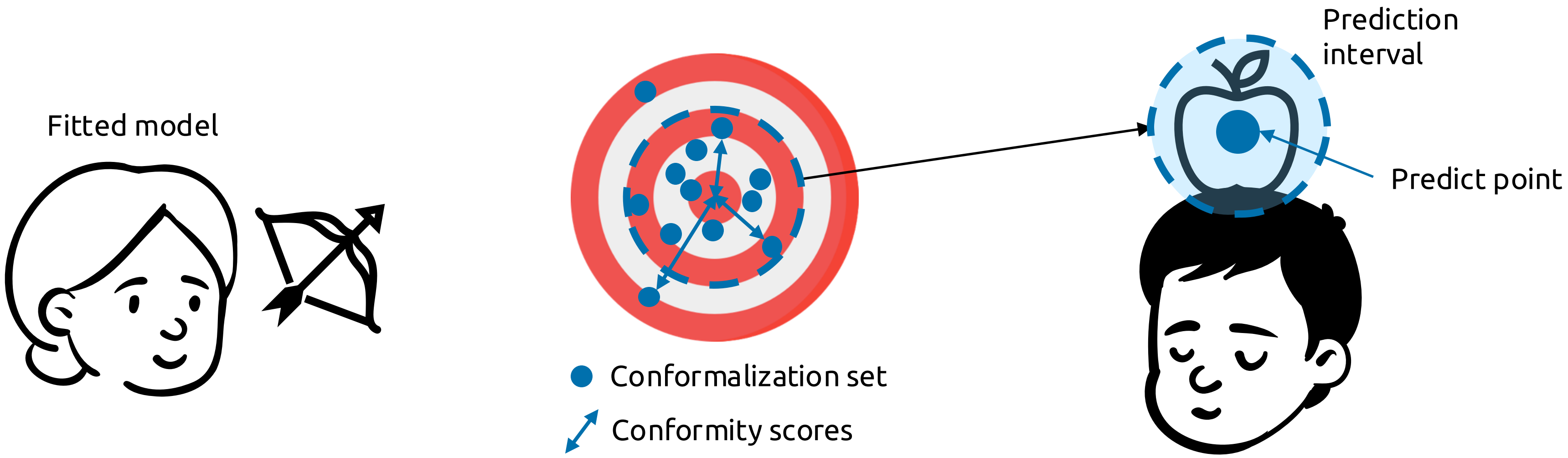
COMING SOON

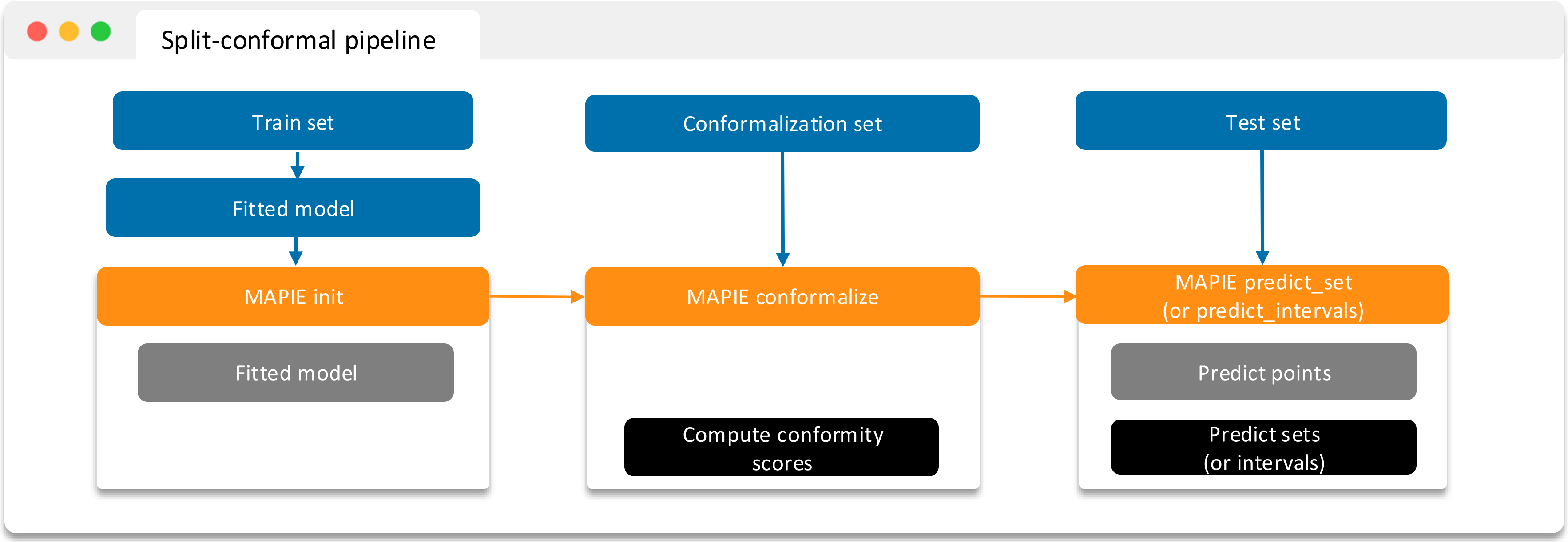
The shingles vaccine is typically recommended for adults aged 50 and older. The vaccine is g... in two doses, with the second ... be administered 2 to 6 mon... first dose. ~~It is currently recommended that individuals re... the shingles vaccine once in their lifetime.~~ However, it is always best to consult with a healthcare provider for personalized recomme...

CENSORED

ChatGPT

Conformal prediction in three steps



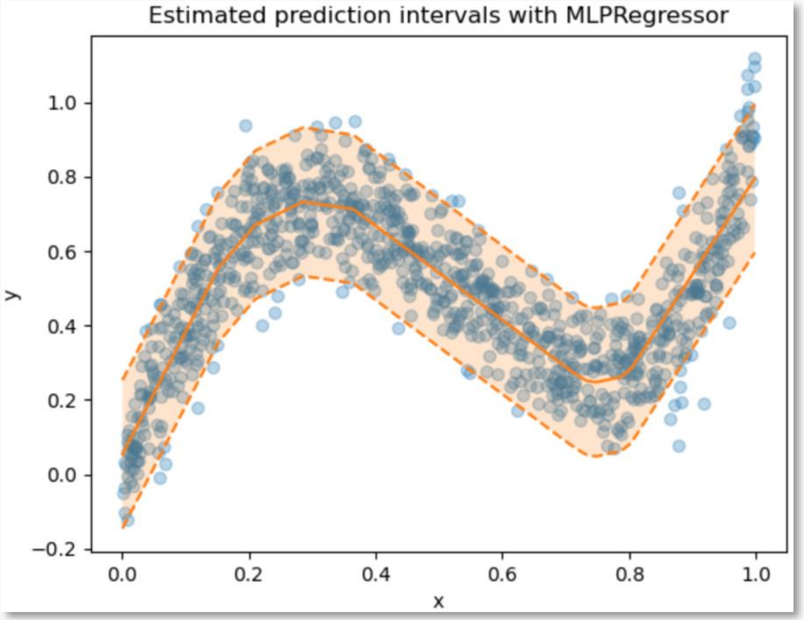


Prefitted model

Practical code snippets

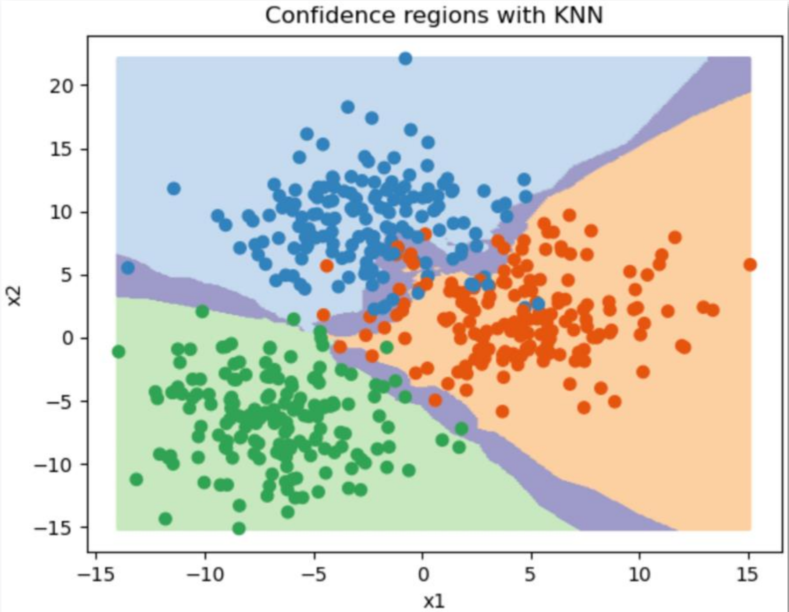
Regression

```
regressor = MLPRegressor(activation="relu", random_state=RANDOM_STATE)
regressor.fit(X_train, y_train)

confidence_level = 0.95
mapie_regressor = SplitConformalRegressor(
    estimator=regressor, confidence_level=confidence_level, prefit=True
)
mapie_regressor.conformalize(X_conformalize, y_conformalize)
y_pred, y_pred_interval = mapie_regressor.predict_interval(X_test)
```



Classification

```
classifier = KNeighborsClassifier(n_neighbors=10)
classifier.fit(X_train, y_train)

confidence_level = 0.95
mapie_classifier = SplitConformalClassifier(
    estimator=classifier, confidence_level=confidence_level, prefit=True
)
mapie_classifier.conformalize(X_conformalize, y_conformalize)
y_pred, y_pred_set = mapie_classifier.predict_set(X_test)
```



What’s next ?

MAPIE roadmap

Focused improvements and exciting new directions!

What's new

- **MAPIE v1**: major release to enhance usability
  - *Reworked documentation*
  - *New, modular API*
  - *Updated dependencies*
  - *Comprehensive release notes*
- **MAPIE v1.1:** first iteration of risk control for binary classification
- **France 2030 support**: 1 engineer from Inria to help improve the library

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FRANCE 2030

Priorities

- **Risk control:** further develop the binary classification setting, to enable controlling LLM-based systems
- **Adaptivity:** Focus on conditional coverage (VS marginal coverage)

Next up

- Exchangeability hypothesis testing
- Feedback and suggestions welcome!

MAPIE team & contributors

MAPIE Team


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Affiliations and Financial Supports

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Quantmetry
Part of Capgemini Invent

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Région îledeFrance

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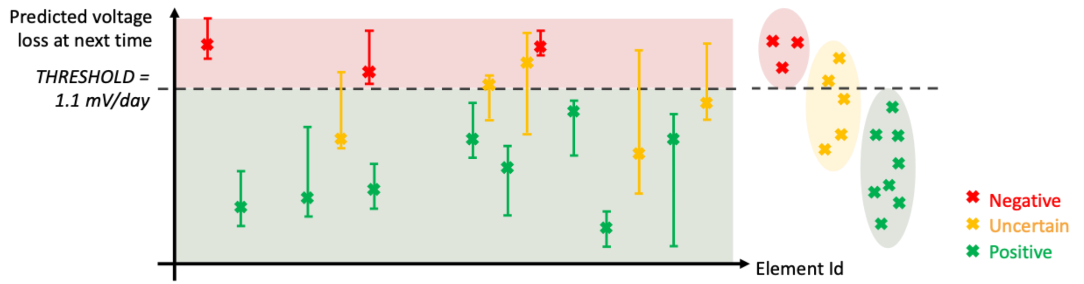
Confiance ai

Contributors of MAPIE

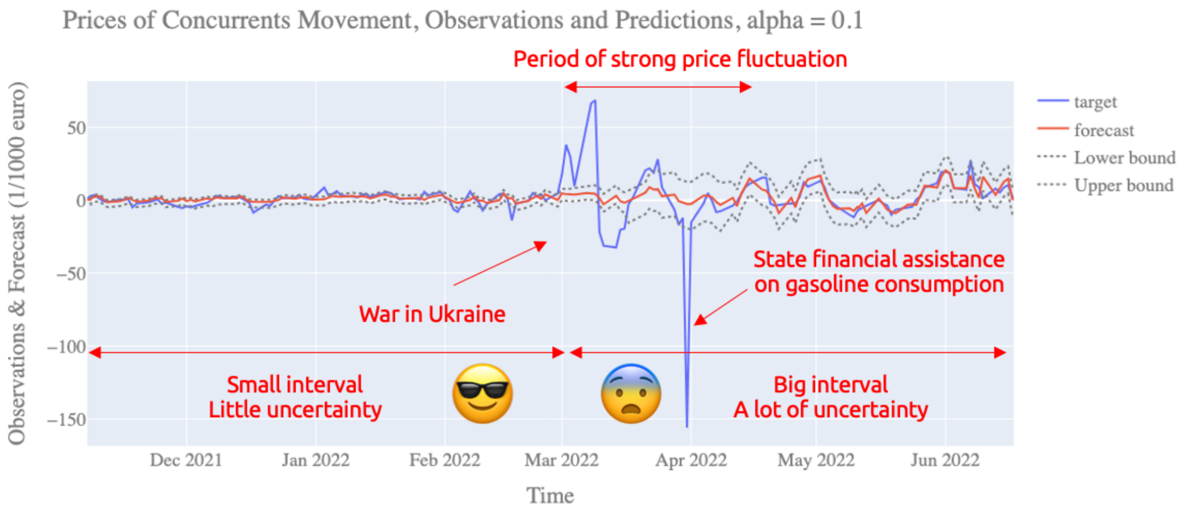
They use MAPIE

Focus on faulty battery detection

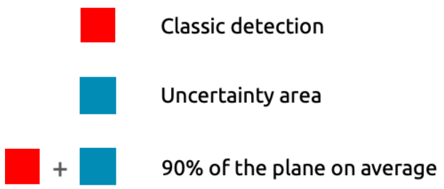


Conformalized Quantile Regression: Capture noise variability (heteroscedasticity)

Focus on predicting price movements



Segmentation of plane identification in pictures



Q&A

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