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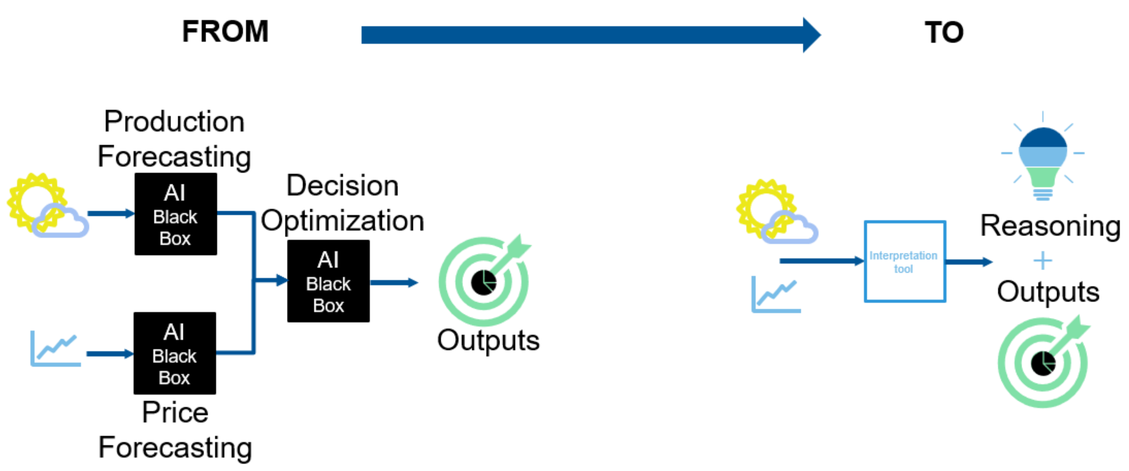
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Towards increased interpretability of AI-tools in the energy sector with focus on the wind energy trading application

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Context and Motivation

- **Artificial Intelligence (AI)** based tools have proven their efficiency in various applications in the energy sector ranging from forecasting to optimization and decision making.
- However, AI-based tools are often seen as **black-box models** and this penalizes their **acceptability** by end-users (traders, power system operators a.o.).
- **Developing interpretable of AI tools is a major challenge** for the wider adoption of AI in the energy sector.



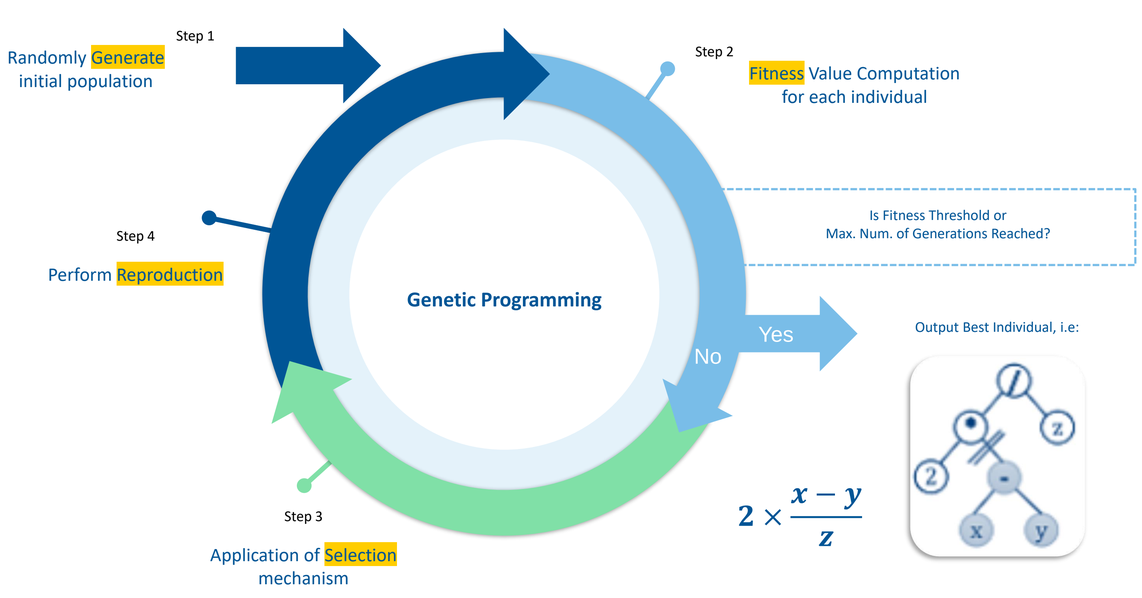
Objectives

- Proposal and validation of a **data-driven modeling approach** that leverages **genetic programming (GP)** to derive interpretable decisions.
- The proposed approach should permit to **reduce modelling complexity** of various forecasting AI-tools to just one single data-driven model.
- We illustrate the applicability to the problem of **trading wind production** to energy markets while minimizing imbalance costs
- We **compare to the standard state-of-the-art** approach. However the aim is not necessarily to outperform in terms of generated revenue, but rather to **improve transparency and reduce complexity** by creating data-driven ad-hoc interpretable strategies that perform equally well to the state of the art.

Methods

We are using **Symbolic Regression (SR)** from **Genetic Programming** algorithm to derive **interpretable analytical expressions** that represent our model.

Those equations result according to a value-oriented reward function. The optimal solutions are selected naturally mimicking the biological theory of survival of the fittest. After the production of several individual tree structures that represent the analytical expressions, reproduction mechanisms are utilized to proceed to the next generation of analytical solutions, until we meet a determined threshold.



We propose a fitness metric tailored to the trading of a dual market price which is formed as follows:

$$\rho^{dual} = \pi^{da} p^{E} - \underbrace{\left[-\lambda^{\uparrow}\left(p^{E} - p^{offer}\right)^{-} + \lambda^{\downarrow}\left(p^{E} - p^{offer}\right)^{+}\right]}_{imbalance\ cost}$$

where ρ^{dual} is the revenue obtained by bidding ρ^{offer} when the actual energy produced is equal to ρ^{E}. The decision derived from GP is defined as Z.

The objective is to minimize the imbalance cost of our trading decisions as well the complexity of the final decision. The metric for complexity is:

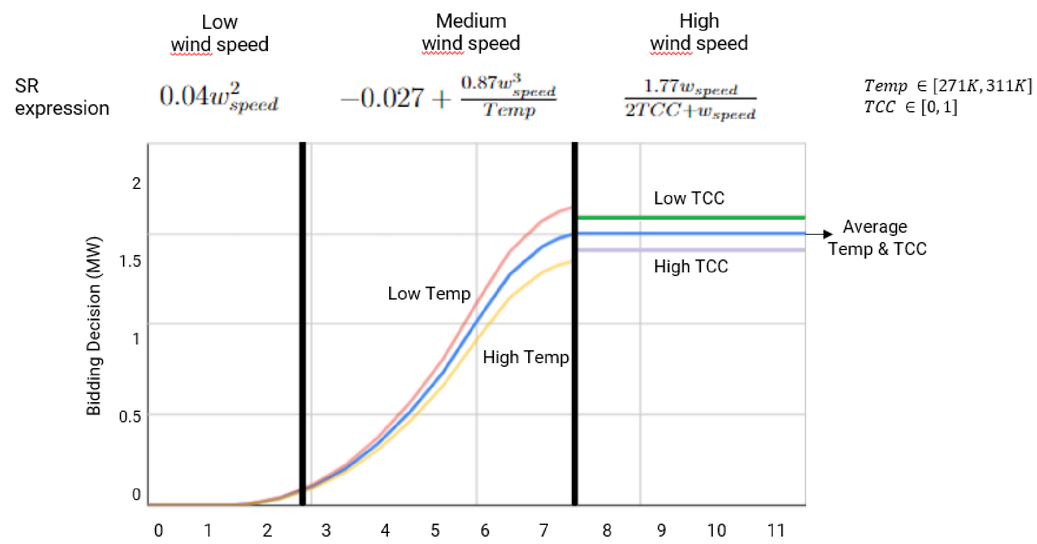
$$op(Z) = \frac{\mathrm{len}(Z) - 1}{2}$$

Results

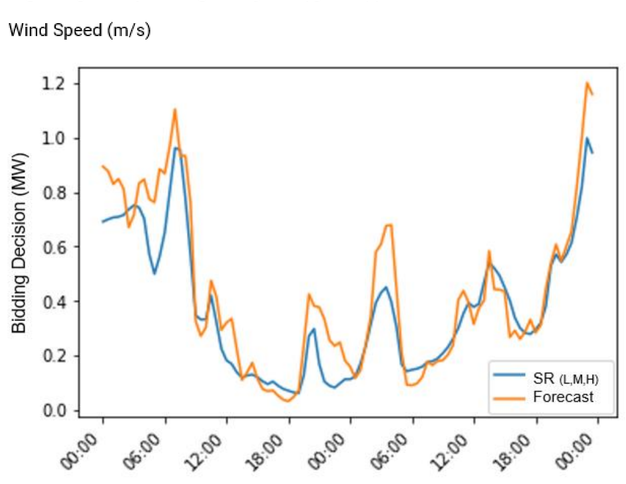
Case study:

- Four wind turbines of 2 MW each located in France.
- 2 years of production data split into learning and testing sets.
- Weather forecasts from ECMWF, Market prices from EPEX SPOT.

A Trading strategy is derived for each Wind Turbine (WT) from a GP/SR model conditioned by clusters of wind speed forecast.



GP / SR trading strategy builds an interpretable bidding curve from data, where the wind speed forecast is the key driver, while it is inversely correlated to cloud coverage (TCC) and temperature (Temp).



Revenues (in €) of the testing period for each of the WTs:

Selected Strategy	WT_1	WT_2	WT_4	WT_4
Bidding perfect hindsight	272.209	264.449	254.960	253.068
A: Reference Bidding	257.158	241.241	238.468	238.145
B: SR_{Global}	238.632	228.124	219.630	219.744
C: $SR_{(LowMedium,High)}$	250.051	241.338	232.002	231.072

Conclusions

By training a model with weather variables as the only input, we managed to derive interpretable trading decisions with a single SR model. The model performed better when a clustering based on wind speed was applied.

Acknowledgements

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