Artificial intelligence and signal decomposition approach applied to retail sales forecasting

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INTRODUCTION

- Sales forecasting is **essential for decision-making**, once these forecasts are important inputs to **managerial decisions**, such as **pricing**, **store space allocation**, **inventory management**, and others.
- Further, sales predictions are crucial for firms in many areas, such as **planning and scheduling**, **marketing**, **logistics**, and **supply chain**.
- Moreover, the behavior of retail sales **fluctuates widely**, making it **difficult** to forecast **as accurate as possible**.

INTRODUCTION

- Due to these factors, forecasting sales is a **challenging task**.
- **Ensemble Empirical Mode Decomposition (EEMD)** can handle the time series.
- Diverse **artificial intelligence (AI) models** for multi-step ahead forecasting

OBJECTIVE

- The objective of this study is to **propose a decomposition framework to forecast the retail sales of a Rossmann Store**, using a multi-step ahead strategy (one, seven, and fourteen days ahead).
- The proposed model is composed by **EEMD** and **heterogeneous AI approaches**.

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DATASET DESCRIPTION

- The dataset refers to the **Rossmann Store Sales dataset** available on **Kaggle** [1].
- The **Rossmann Store #415** was randomly chosen, and the time horizon comprises from **January 1st** to **July 31st 2015**.
- The days which the **store was closed**, whether for holidays or Sundays, were **suppressed** from the analysis due to **no sales**.
- The only numerical variable (**number of customers**) was used in the forecasting.

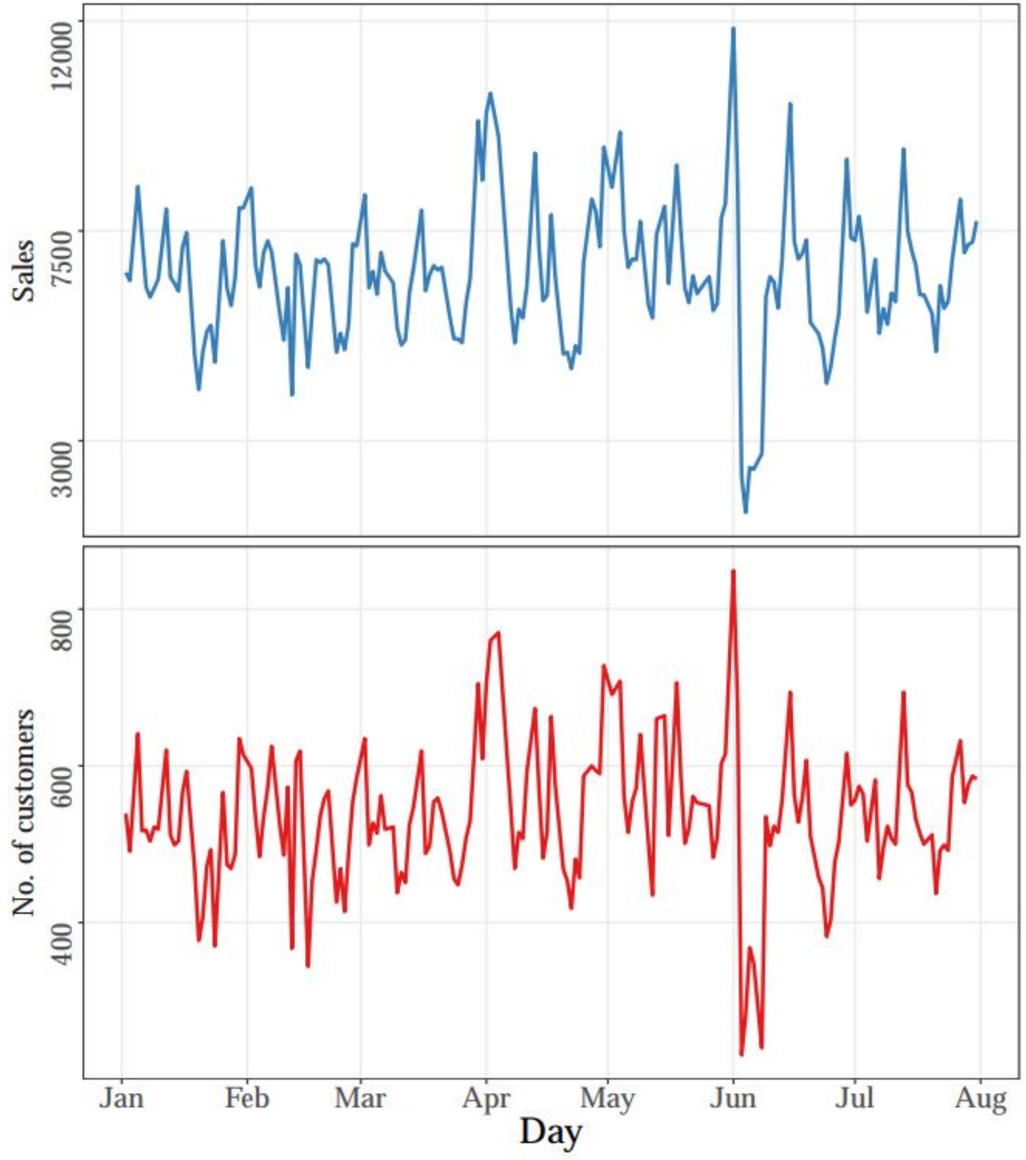

Fig. 2. Sales and customers numbers - historical series of the Rossmann Store #415

METHODOLOGY

- **EEMD** decomposed the data into 6 components.
- Three different algorithms:
  - **BRNN** (Bayesian Regularized Neural Network).
  - **CUBIST** Regression.
  - **SVR** (Support Vector Regression with Radial Basis Function kernel).
- Performance measures:
  - **MAPE** (Mean absolute percentage error).
  - **RMSPE** (Root mean squared percentage error).

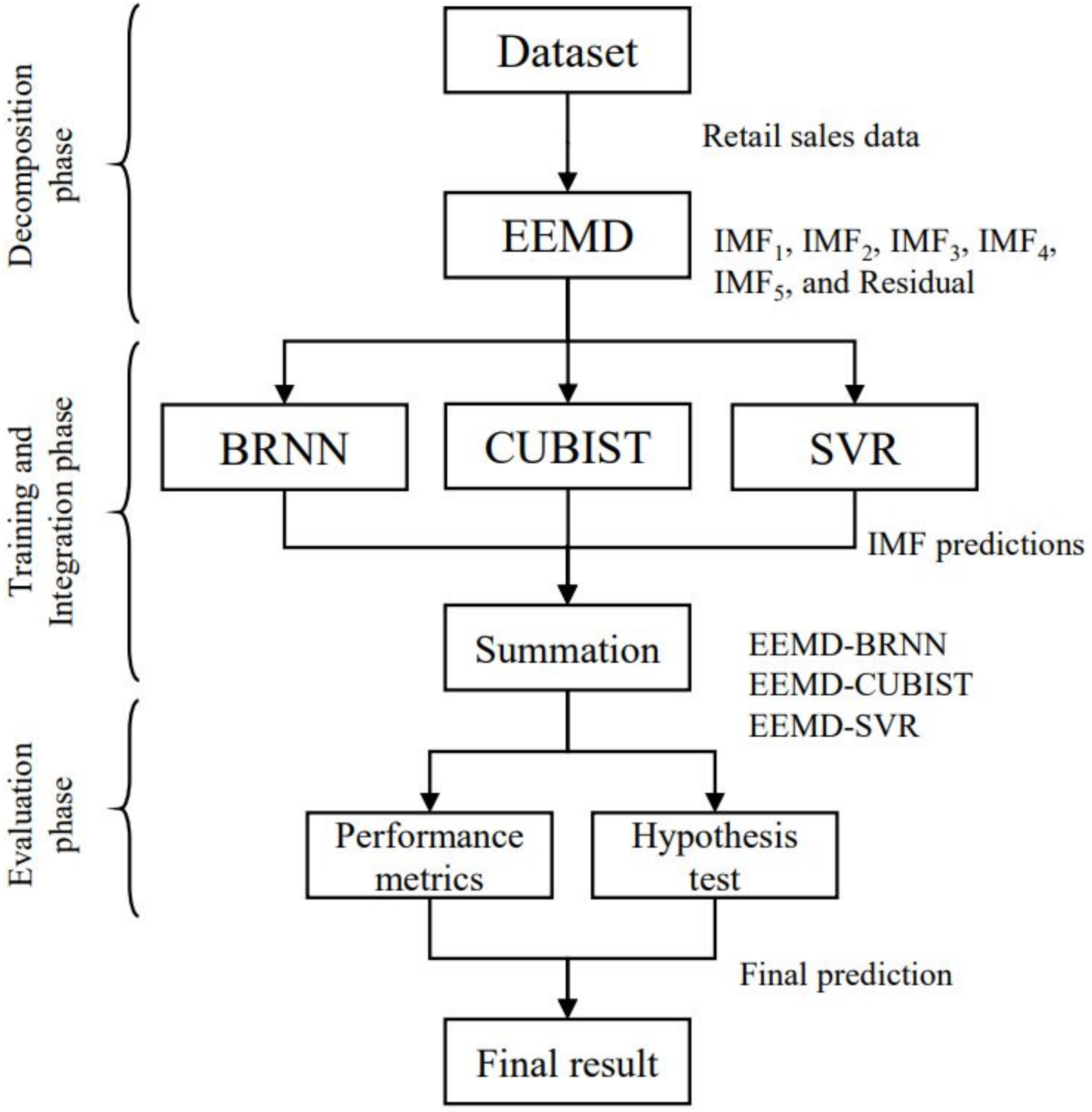

Fig. 4. Framework of the proposed forecasting models

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RESULTS

TABLE III
PERFORMANCE MEASURES RESULTS OF THE MODELS

Models	1-day-ahead		7-days-ahead		14-days-ahead	
	MAPE	RMSPE	MAPE	RMSPE	MAPE	RMSPE
EEMD-BRNN	**8.27%**	**16.77%**	17.77%	31.85%	20.66%	33.77%
EEMD-CUBIST	8.95%	20.14%	**17.54%**	**28.89%**	19.35%	**30.75%**
EEMD-SVR	15.08%	63.27%	18.44%	65.37%	**18.85%**	65.59%
BRNN	16.16%	54.65%	19.10%	75.94%	21.06%	76.19%
CUBIST	15.90%	47.86%	19.38%	77.67%	19.67%	77.67%
SVR	16.43%	70.63%	19.14%	70.23%	21.64%	70.64%

TABLE IV
STATISTICS OF DM TEST FOR STATISTICAL COMPARISON OF PROPOSED APPROACH VERSUS OTHER MODELS

Model	One-day-ahead (A)	Seven-days-ahead (B)	Fourteen-days-ahead (B)
(A) EEMD–BRNN	-	-0.4019	-1.0146
(B) EEMD–CUBIST	-0.7518	-	-
(C) EEMD–SVR	-3.3240*	-0.8293	-0.2719
(D) BRNN	-3.8176*	-0.8977	-0.5537
(E) CUBIST	-3.2382*	-0.8866	-0.3867
(F) SVR	-3.2614*	-0.7028	-0.5462

Note: *1% significance level.

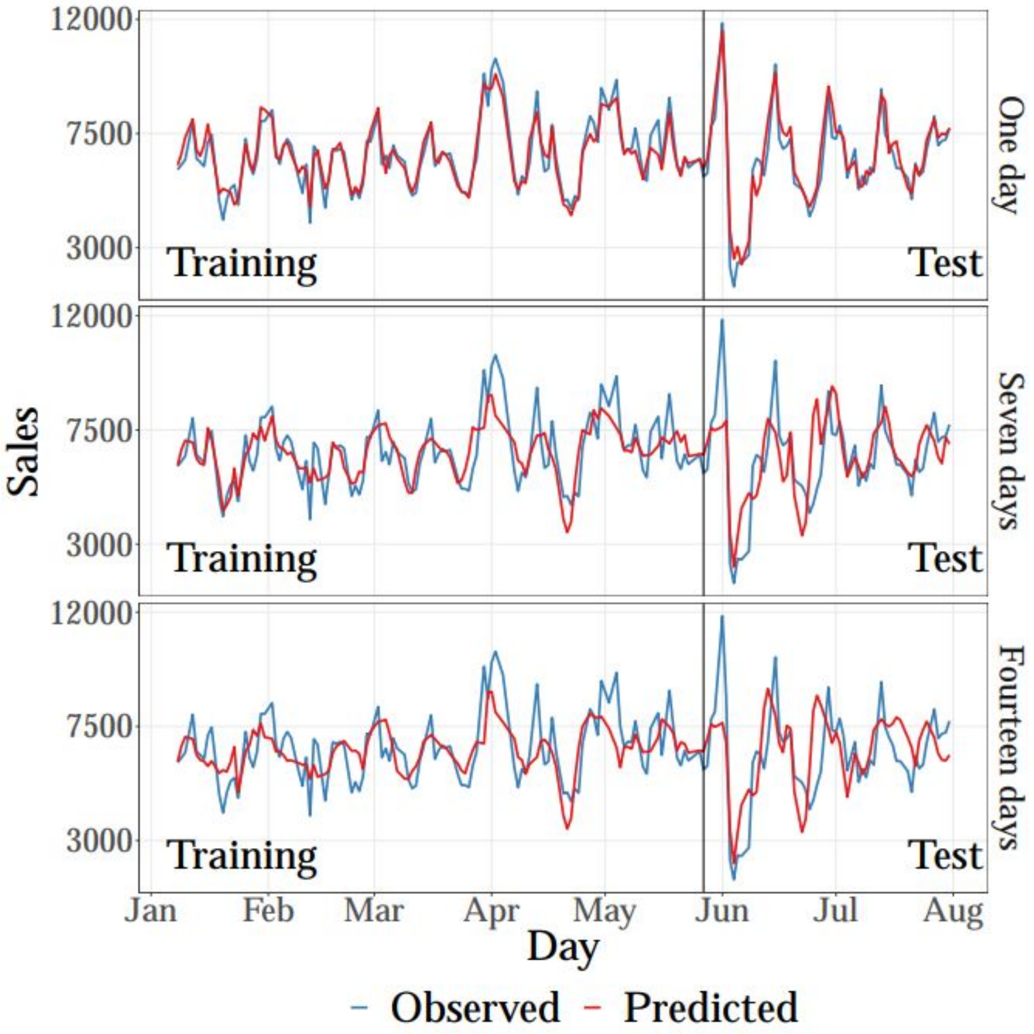

Fig. 5. Observed versus predicted values in all forecasting horizons

CONCLUSION

- This study proposed a decomposition framework by using **EEMD** and **AI models** to forecast retail sales multi-step ahead.
- The **EEMD** was coupled with **BRNN**, **CUBIST**, and **SVR** as forecasting models.
- Indeed, the **EEMD-based approaches** had a **better** performance than compared models in all forecasting horizons.
- **For future works**
  - Coupling stacking ensemble learning approach.
  - Adopting different signal decomposition approaches.
  - Optimizing the hyperparameters of the forecasting models by using multi-objective optimization.

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REFERENCES

[1] Kaggle, “Rossmann Store Sales: Forecast sales using store, promotion, and competitor data,” 2015. [Online]. Available: https://www.kaggle.com/c/rossmann-store-sales

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Thank you!

Any questions?

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