Dengue Cases Forecasting Based on eXtreme Gradient Boosting Ensemble with Coyote Optimization

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AGENDA

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- Objective
- Dataset description
- Methodology
- Results
- Conclusion
- References

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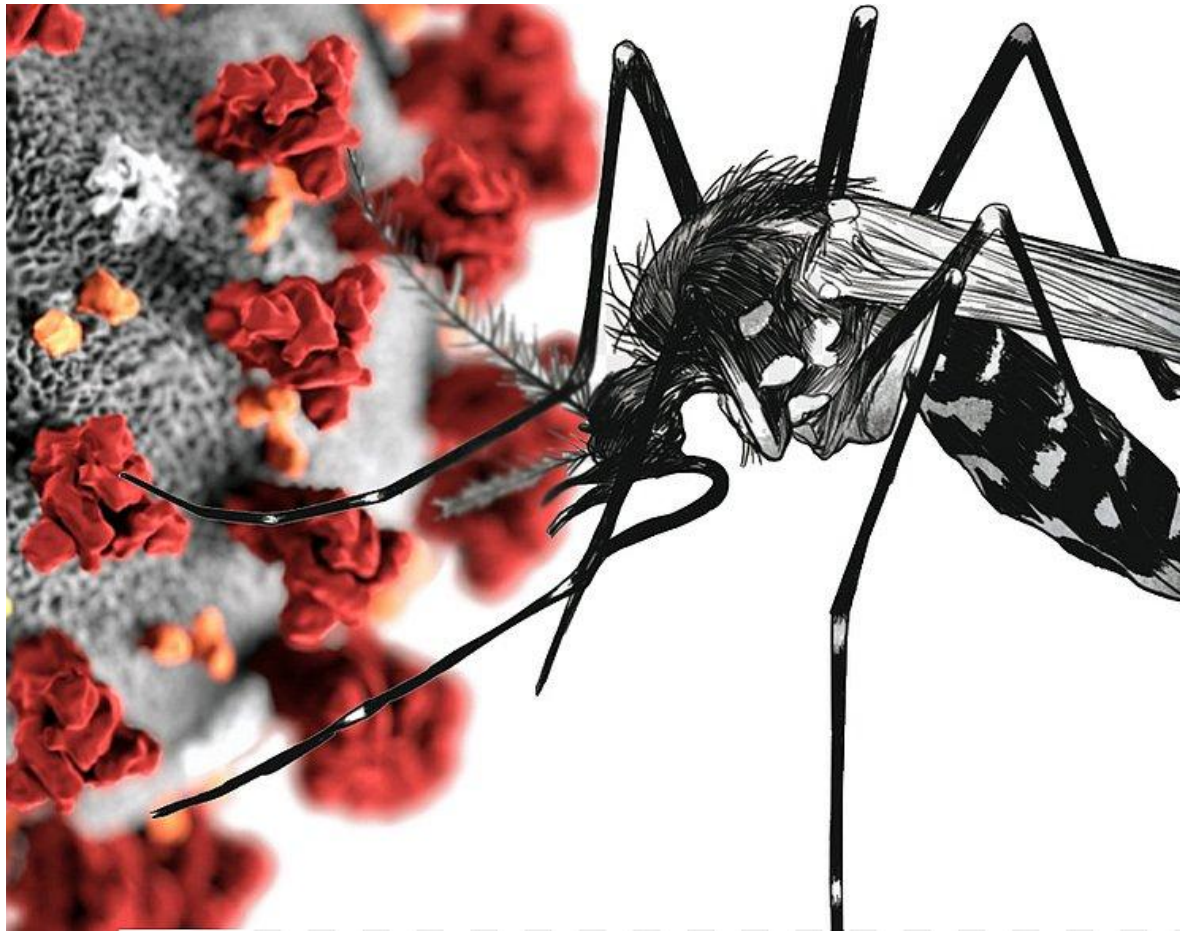
INTRODUCTION

- Dengue is considered a **public health problem in tropical regions.** The development of efficient forecasting models is important **to supporting health care** officials to optimally **disseminate available resources** in the dengue-prone areas.
- In **2020** in **Brazil**, there were **979,764 probable cases** reported (incidence rate of **466.2 cases per 100** thousand inhabitants) (Brazil, 2020).
- There are a **limited number of studies** devoted to obtaining **efficient forecasting models** worldwide, especially for the **Brazil** case (Hoyos et al., 2021).

INTRODUCTION

- Climatic, demographic, and social factors makes the development of forecasting models a **challenging task**.
- **Cooperative Ensembles models** can handle with that the time series.
- Hybridize **eXtreme gradient boosting (XGBoost)** with **metaheuristics** for **hyperparameters tuning** can be a suitable approach for that.



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OBJECTIVE

- The objective of this study is to **explore the viability of using the Coyote Optimization Algorithm (COA)** (Pierezan and Coelho, 2018), to tuning the XGBoost hyperparameters for the task of **forecasting multi-step-ahead dengue** incidence in Parana, Brazil.

DATASET DESCRIPTION

- The dataset refers to the **Dengue cases number in PR** available on **DATASUS**.
- Dengue cases is the **output** variable.
- Lagged values of dengue and exogenous variables such as **precipitation** (mm), **maximal and minimum temperature** (°C), **thermal amplitude**, and **humidity** are considered as **features**.

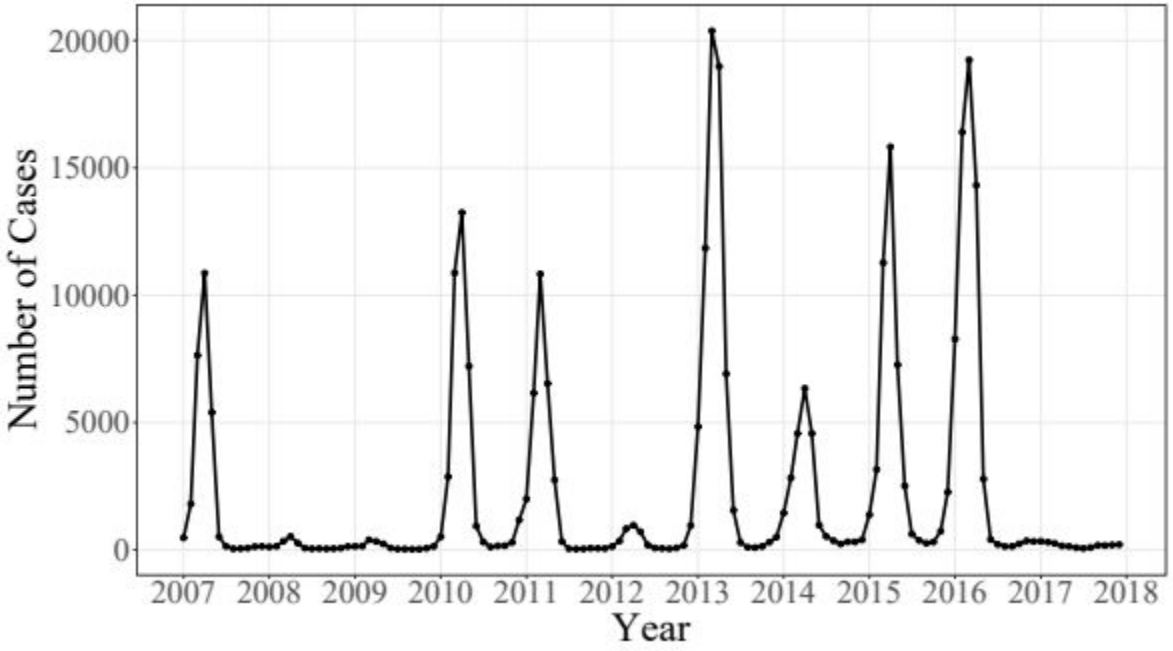

Figure 1: Dengue cases over the time for PR state.

METHODOLOGY

- **XGBoost** with linear booster is used.
- Five different optimization methods c adopted for comparison:
  - **CS** (Cuckoo Search Optimization).
  - **DE** (Differential Evolution).
  - **FFA** (Firefly Algorithm).
  - **GWO** (Grey Wolf Optimzer).
  - **GA** (Genetic Algorithm).
- Performance measures:
  - **MAPE** (Mean absolute percentage error).
  - **RMSE** (Root mean squared error).

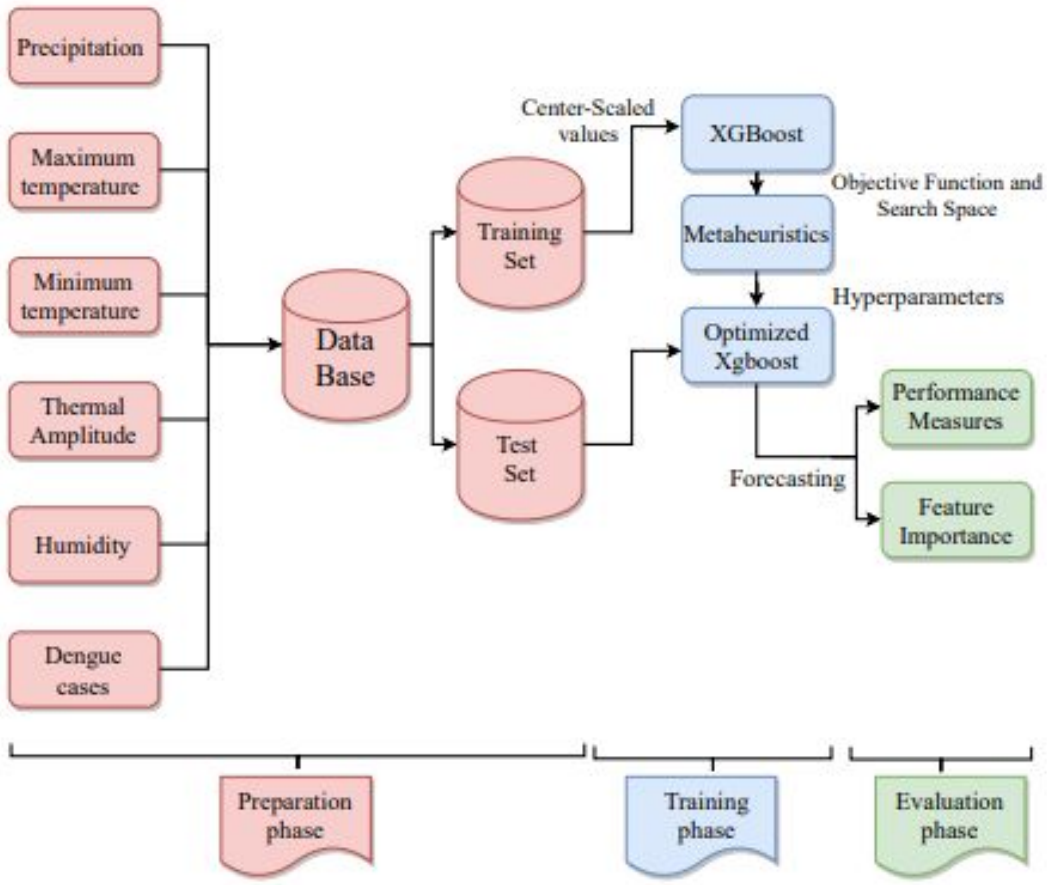

Figure 2: Flowchart of proposed workflow.

RESULTS

RESULTS OF THE OPTIMIZED XGBOOST MODEL IN TERMS OF RMSE AND MAPE (30 RUNS) TO FORECAST DENGUE CASES ONE UP TO THREE-MONTHS-AHEAD.

Forecasting Horizon	Statistical Indicator	COA RMSE	COA MAPE	CS RMSE	CS MAPE	DE RMSE	DE MAPE	FFA RMSE	FFA MAPE	GA RMSE	GA MAPE	GWO RMSE	GWO MAPE
One-Month-Ahead	Minimum	**1713.02**	0.84	1731.29	0.89	1731.15	0.86	1729.77	0.90	1714.62	**0.78**	1729.11	0.90
	Median	1766.03	**0.95**	1789.70	1.05	1804.11	1.10	1794.90	1.09	1775.90	0.98	**1764.10**	1.04
	Arithmetic Average	**1781.11**	1.04	1822.97	1.07	1867.30	1.10	1838.31	**1.01**	1782.03	1.03	1798.53	1.05
	Maximum	2324.51	1.37	2367.71	1.32	2469.16	1.33	2365.05	1.33	**1952.43**	**1.31**	2027.33	1.32
	Std	106.51	0.16	125.53	0.14	169.64	0.15	158.45	0.16	**48.44**	0.15	88.34	**0.12**
	Trimmead Average	**1771.63**	**1.03**	1806.79	1.07	1850.67	1.10	1823.37	1.10	1778.35	1.03	1792.84	1.05
Two-Months-Ahead	Minimum	2137.04	1.66	2134.07	1.76	2119.51	1.77	2149.11	1.67	**1972.87**	**1.47**	2148.96	1.67
	Median	**2255.32**	**2.01**	2308.71	2.08	2359.21	2.11	2342.11	2.05	2267.86	2.03	2285.98	2.06
	Arithmetic Average	**2304.89**	**2.01**	2414.14	2.12	2452.36	2.16	2482.09	2.09	2325.46	2.05	2470.95	2.12
	Maximum	2579.12	**2.35**	3459.93	2.83	3485.67	2.89	3524.81	2.90	**2578.88**	2.36	3521.92	2.90
	Std	**122.48**	**0.18**	314.00	0.23	363.39	0.28	356.59	0.27	145.87	**0.18**	424.53	0.36
	Trimmead Average	**2301.09**	**2.01**	2386.79	2.10	2427.34	2.15	2456.74	2.08	2329.00	2.06	2444.91	2.11
Three-Months-Ahead	Minimum	4648.69	3.94	4359.29	3.12	4481.53	3.44	4329.44	**2.88**	**4098.81**	3.90	4712.15	3.92
	Median	**4716.16**	6.19	4807.40	**5.09**	4944.75	5.34	4925.31	5.27	4794.93	6.14	4912.82	5.79
	Arithmetic Average	**4837.34**	5.93	4886.85	5.45	4968.31	5.62	4965.94	**5.50**	4841.11	5.87	5001.54	5.86
	Maximum	**5128.22**	7.56	5744.22	**7.55**	5781.80	7.96	5828.92	7.55	5198.96	8.01	5787.45	7.62
	Std	**119.14**	1.32	268.26	1.45	286.06	1.37	306.57	1.36	201.01	1.42	319.13	**1.27**
	Trimmead Average	**3577.82**	3.90	3630.58	**3.68**	3687.54	3.80	3706.88	3.71	3579.39	3.88	3711.34	3.92

RESULTS

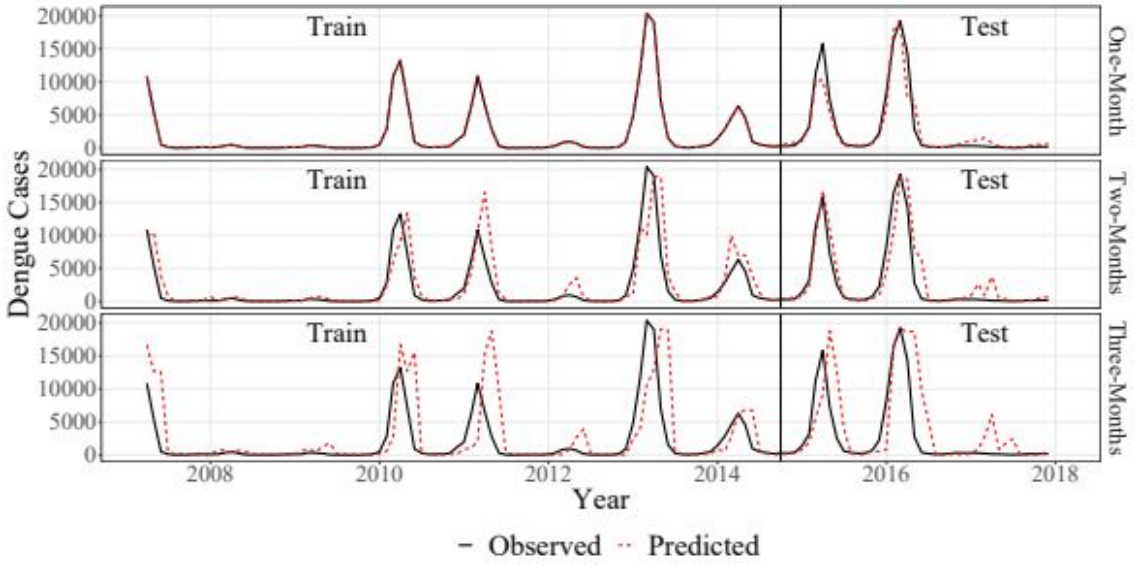

Figure 3: Predicted versus observd values.

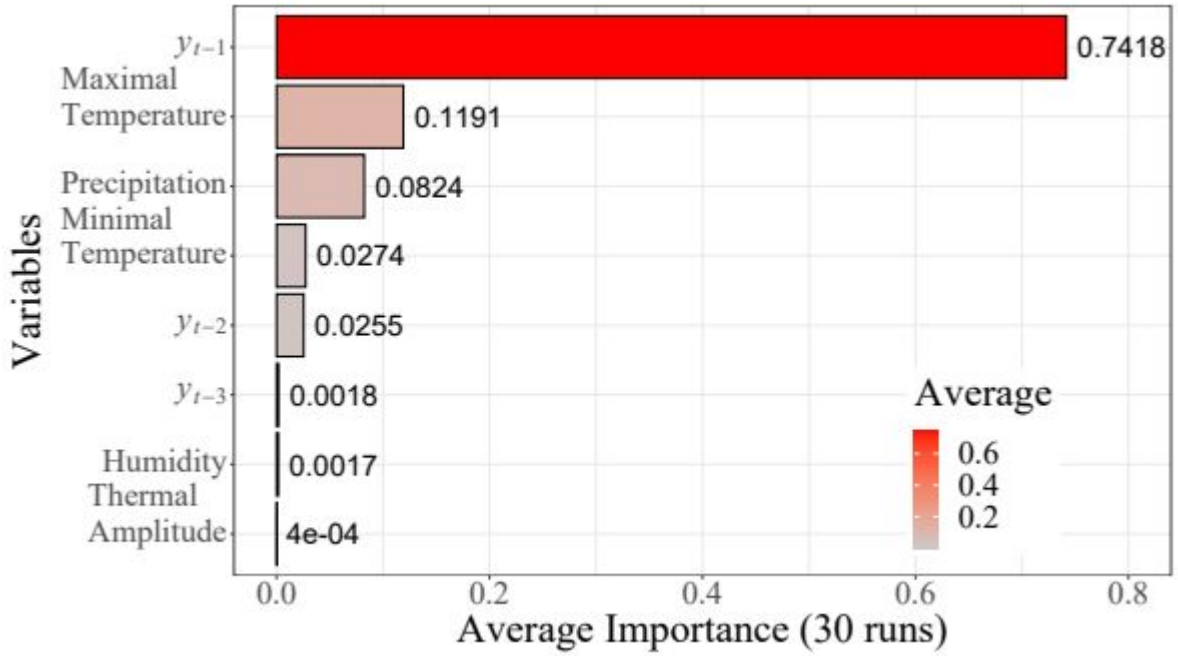

Figure 4: Feature Importance.

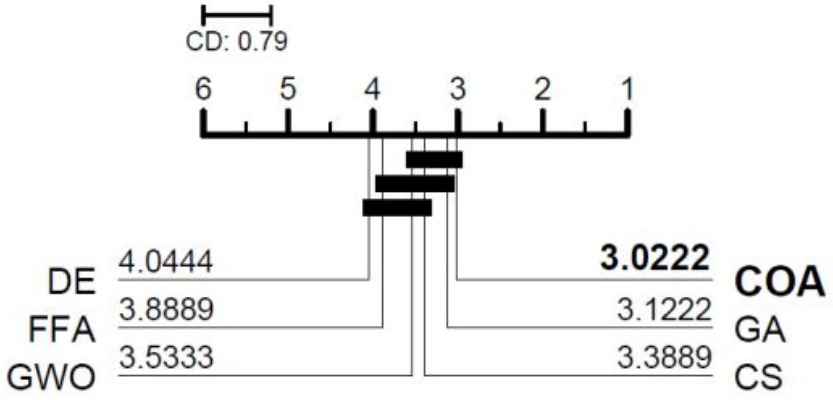

Figure 5: CD plot for RMSE.

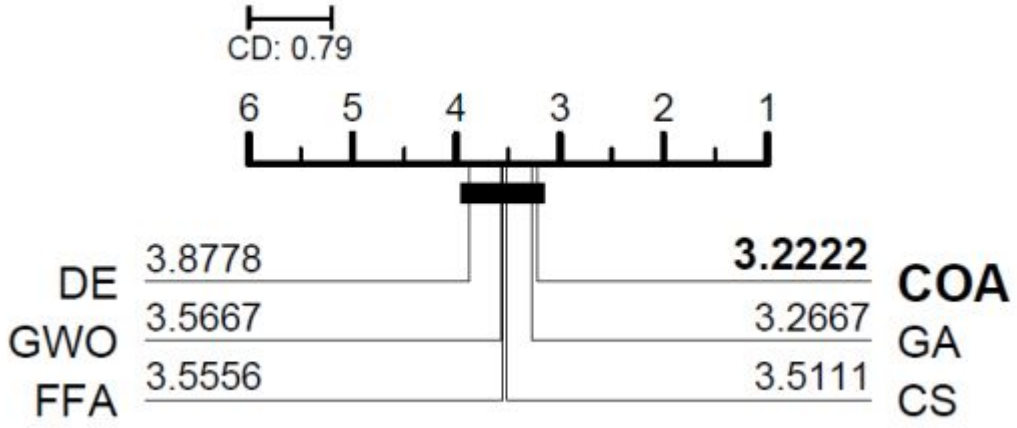

Figure 6: CD plot for MAPE.

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CONCLUSION

- This study proposed a novel combination of **COA** and **XGBoost** to forecast **dengue** cases multi-step-ahead for PR state.
- The performance of the proposed XGBoost model using COA was compared with XGBoost coupled with **DE, CS, COA, DE, FFA, GA**, and **GWO** for **hyperparameters tuning**.
- **Regarding accuracy** (average of RMSE and MAPE, over 30 runs), the proposed **COA-XGBoost outperforms** compared approaches.
- The **ranking** of **feature importance** is dengue cases lags, maximal temperature, precipitation, minimal temperature, humidity, and thermal amplitude.
- **For future works**
  - Performing spatio-temporal analysis.
  - Comparing COA-XGBoost with artificial neural networks and state-of-art methods.

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ACKNOWLEDGMENTS

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Thank you!

Any questions?

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