Anomaly Detection in Ibovespa time series using topological data analysis

Laura Alves Pacifico da Silva[1], Wilson Rosa de Oliveira Júnior[2]

[1] Universidade Federal de Pernambuco

[2] Universidade Federal Rural de Pernambuco

Abbreviated abstract: In this work, we apply Topological Data Analysis techniques more precisely, we use persistent homology to calculate more persistent topological characteristics in data of the Ibovespa time series, from April 27, 1993, to April 14, 2021. We use persistence diagrams to represent the outputs obtained and we use the landscape distances to evaluate the comportment of the series in the 2008 - 2009 crisis and COVID-19 crisis. The results obtained showed that periods of high volatility preceding a crash produce geometric signatures that can be more robustly detected using topological data analysis.

Related publications:

– Gidea, Marian, and Yuri Katz. "Topological data analysis of financial time series: Landscapes of crashes." *Physica A: Statistical Mechanics and its Applications* 491 (2018): 820-834.

- Bubenik, Peter. "The persistence landscape and some of its properties." *Topological Data Analysis*. Springer, Cham, 2020. 97-117.

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Problem, Data, Previous Works

- In previous studies, topological data analysis was used to quantify patterns in time series of signals, to understand the nature of chaotic attractors in the phase space of complex dynamical systems and classifying time series using persistent homology and convolutional neural network.

- In this work we propose to analyze the evolution of the daily returns of the Brazilian index Ibovespa, during crisis periods: the financial crisis of 2007-2009 and pandemic of COVID-19 in 2020 using persistent homology (TDA) to detect and quantify topological patterns that appear in time series.

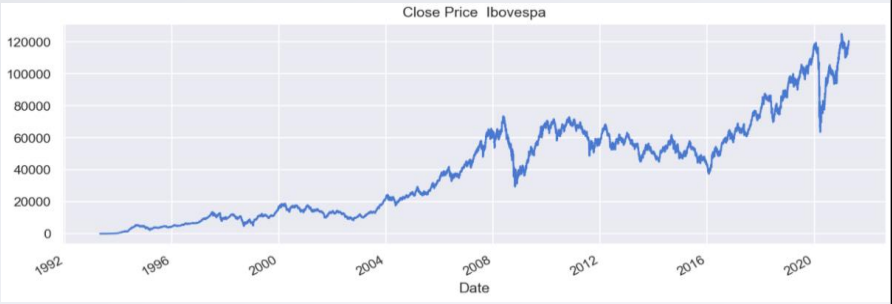
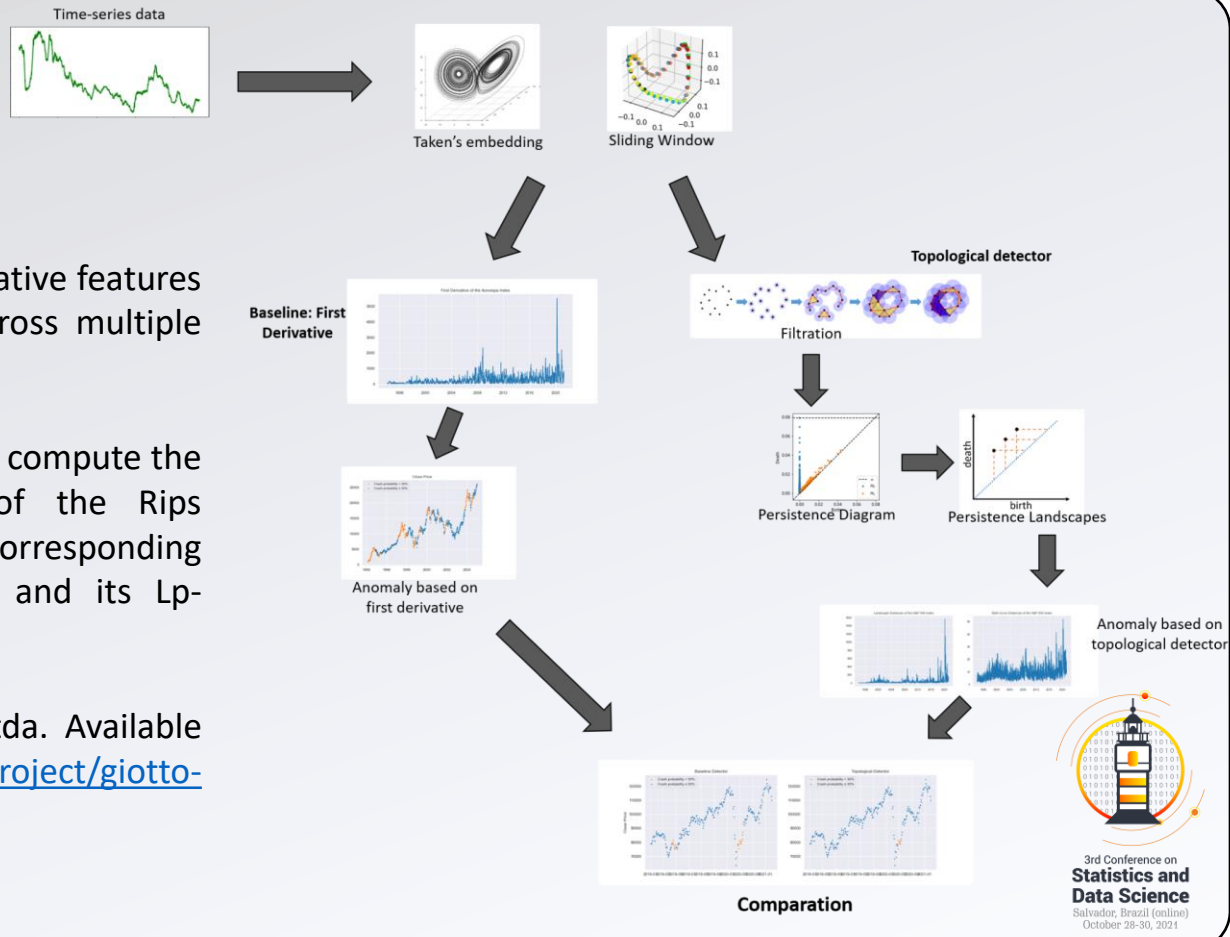


Figure 1: Close Price time series of Ibovespa index

Methods

Persistent Homology :

- Used for to study qualitative features of data that persist across multiple scales;
- For each point cloud we compute the persistence diagram of the Rips filtration, the corresponding persistence landscape, and its Lp-norms;
- Pyhton Library: giotto-tda. Available in: https://pypi.org/project/giotto-tda



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Results and Conclusions

- Topological data analysis proves to be a very useful tool for econometric analysis and reveals that the shape of financial time series strongly depends on the state of the market;

- Our results suggest that the periods of high volatility preceding a crash produce geometric signatures that can be more robustly detected using topological data analysis.

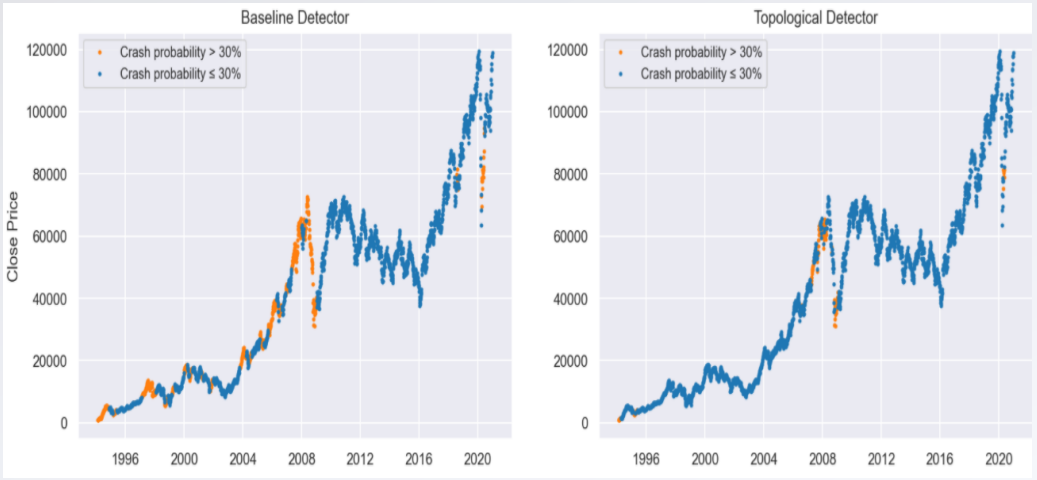

Figura 3: Crash probabilities and detections using topological features.

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