

Forecasting Financial Time Series with Grammar-Guided Feature Generation

Anthony Mihirana de Silva , Richard I. A. Davis, Syed A. Pasha, Philip H. W. Leong

First published: 04 January 2016

<https://doi.org/10.1111/coin.12083>



Abstract

The application of machine learning techniques to forecast financial time series is not a recent development, yet it continues to attract considerable attention because of the difficulty of the problem that is compounded by the nonlinear and nonstationary nature of the time series. The choice of an appropriate set of features is crucial to improve forecasting accuracy of machine learning techniques. In this article, we propose a systematic way for generating rich features using context-free grammars. Our proposed methodology identifies potential candidates for new technical indicators that consistently improve forecasts compared with some well-known indicators. The notion of grammar families as a compact representation to generate a rich class of features is exploited, and implementation issues are discussed in detail. The proposed methodology is tested on closing price data of major stock market indices, and the forecasting performance is compared with some standard techniques. A comparison with the conventional approach using standard technical indicators and naive approaches is shown.

References

Brockwell, P. J., and R. A. Davis. 2002. *Introduction to Time-Series and Forecasting*. Springer: New York.

[Google Scholar](#) 

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

Ding, C., and H. Peng. 2003. Minimum redundancy feature selection from microarray gene expression data,. *In Proceedings of the IEEE Computer Society Conference on Bioinformatics*. CSB '03. IEEE Computer Society, Washington, DC. <http://dl.acm.org/citation.cfm?id=937976.938050>.

[Google Scholar](#) 

Eads, D., K. Glocer, S. Perkins, and J. Theiler. 2005. Grammar-guided feature extraction for time-series classification. *In Proceedings of the 9th Annual Conference on Neural Information Processing Systems (NIPS)*, Vancouver, BC.

[Google Scholar](#) 

Edwards, R. D., J. Magee, and W. H. C. Bassetti. 2007. *Technical Analysis of Stock Trends*. CRC Press: Boca Raton, FL.

[Google Scholar](#) 

Espinoza, M., J. Suykens, and B. De Moor. 2005. Load forecasting using fixed-size least squares support vector machines. *In Computational Intelligence and Bioinspired Systems*. Springer: Barcelona, Spain, pp. 1018–1026.

[Google Scholar](#) 

Franke, J., W. Härdle, and C. M. Hafner. 2008. *Statistics of Financial Markets: An Introduction*. Springer: Berlin.

[Google Scholar](#) 

Guo, H., L. B. Jack, and A. K. Nandi. 2005. Feature generation using genetic programming with application to fault classification. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*, 35(1): 89–99.

[PubMed](#)  | [Web of Science®](#)  | [Google Scholar](#) 

Guyon, Issabelle. 2003. An introduction to variable and feature selection. *Journal of Machine Learning Research*, 3: 1157–1182.

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

Hanchuan, P., L. Fuhui, and D. Chris. 2005. Feature selection based on mutual information criteria of max-dependency, max-relevance, and min-redundancy. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 27(8): 1226–1238.

[PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

Hong, G., and A. K. Nandi. 2005. Breast cancer diagnosis using genetic programming generated feature. *In IEEE Workshop on Machine Learning for Signal Processing*, Mystic, CT, pp. 215–220.

[Google Scholar](#)

Huan, L., and Y. Lei. 2005. Toward integrating feature selection algorithms for classification and clustering. *IEEE Transactions on Knowledge and Data Engineering*, 17(4): 491–502.

[Web of Science®](#) | [Google Scholar](#)

Huang, C. L., and C. Y. Tsai. 2009. A Hybrid SOFM-SVR with a filter-based feature selection for stock market forecasting. *Expert Systems with Applications*, 36(2): 1529–1539.

[Web of Science®](#) | [Google Scholar](#)

Huang, S. C., and T. K. Wu. 2008. Integrating GA-based time-scale feature extractions with SVMs for stock index forecasting. *Expert Systems with Applications*, 35(4): 2080–2088.

[Web of Science®](#) | [Google Scholar](#)

Huang, Z., H. Chen, C. J. Hsu, W. H. Chen, and S. Wu. 2004. Credit rating analysis with support vector machines and neural networks: a market comparative study. *Decision Support Systems*, 37(4): 543–558.

[Web of Science®](#) | [Google Scholar](#)

Hyndman, R. J. 2010. Why every statistician should know about cross-validation. Available at: <http://robjhyndman.com/hyndsight/crossvalidation/>. Accessed October 20, 2015.

[Google Scholar](#)

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

Ince, H., and T. B. Trafalis. 2004. Kernel principal component analysis and support vector machines for stock price prediction, 3. *In Proceedings of IEEE International Joint Conference on Neural Networks*, pp. 2053–2058.

[Google Scholar](#)

Islamaj, R., L. Getoor, and W. J. Wilbur. 2006. A feature generation algorithm for sequences with application to splice-site prediction. *In Knowledge Discovery in Databases: Pkdd 2006*. Edited by J. G. Carbonell, and J. Siekmann. Springer: Berlin, pp. 553–560.

[Google Scholar](#)

Jeffrey, A. R. 2013. quantmod: Quantitative financial modelling framework. <http://CRAN.R-project.org/package=quantmod>. R package version 0.4-0.

[Google Scholar](#)

Kamruzzaman, J., and R. A. Sarker. 2003. Forecasting of currency exchange rates using ANN: a case study, 1. *In Proceedings of the International Conference on Neural Networks and Signal Processing*, IEEE, pp. 793–797.

[Google Scholar](#)

Kim, KJ. 2003. Financial time-series forecasting using support vector machines. *Neurocomputing*, 55(1): 307–319.

[Web of Science®](#) | [Google Scholar](#)

Kim, M., S. Min, and H. Ingo. 2006. An evolutionary approach to the combination of multiple classifiers to predict a stock price index. *Expert Systems with Applications*, 31(2): 241–247.

[Web of Science®](#) | [Google Scholar](#)

Knaus, J. 2010. snowfall: Easier cluster computing (based on snow). <http://CRAN.R-project.org/package=snow>

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

Krawiec, K., and B. Bhanu. 2005. Visual learning by coevolutionary feature synthesis. *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*, 35(3): 409–425.

[PubMed](#) | [Web of Science®](#) | [Google Scholar](#)

Krollner, B., B. Vanstone, and G. Finnie. 2010. Financial time-series forecasting with machine learning techniques: a survey. *In Proceedings of the European Symposium on Artificial Neural Networks—Computational Intelligence and Machine Learning*, Bruges, Belgium, pp. 25–30.

[Google Scholar](#)

Lai, T. L., and H. Xing. 2008. *Statistical Models and Methods for Financial Markets*. Springer: New York.

[Web of Science®](#) | [Google Scholar](#)

Lai, R. K., Chin-Yuan Fan, Wei-Hsiu Huang, and Pei-Chann Chang. 2009. Evolving and clustering fuzzy decision tree for financial time-series data forecasting. *Expert Systems with Applications*, 36(2): 3761–3773.

[Web of Science®](#) | [Google Scholar](#)

Lendasse, A., E. de Bodt, V. Wertz, and M. Verleysen. 2000. Non-linear financial time-series forecasting—application to the BEL 20 Stock Market Index. *European Journal of Economic and Social Systems*, 14(1): 81–91.

[Google Scholar](#)

Liang, T., and A. Noore. 2004. A novel approach for short-term load forecasting using support vector machines. *International Journal of Neural Systems*, 14(05): 329–335.

[PubMed](#) | [Google Scholar](#)

Lu, C., T. Lee, and C. Chiu. 2009. Financial time-series forecasting using independent component analysis and support vector regression. *Decision Support Systems*, 47(2): 115–125.

[Web of Science®](#) | [Google Scholar](#)

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

[Google Scholar](#) 

Mohandes, M. 2002. Support vector machines for short-term electrical load forecasting. *International Journal of Energy Research*, 26(4): 335–345.

[Web of Science®](#)  | [Google Scholar](#) 

Noorian, F., A. M. de Silva, and P. H. W. Leong. 2015. gramEvol: Grammatical evolution in R. *Journal of Statistical Software*. To appear.

[Web of Science®](#)  | [Google Scholar](#) 

Pachet, F., and P. Roy. 2009. Analytical features: a knowledge-based approach to audio feature generation. *EURASIP Journal on Audio, Speech, and Music Processing*, 2009(1): 1–23.

[Web of Science®](#)  | [Google Scholar](#) 

Ritanjali, M., G. Panda, B. Majhi, and G. Sahoo. 2009. Efficient prediction of stock market indices using adaptive bacterial foraging optimization (ABFO) and BFO based techniques. *Expert Systems with Applications*, 36(6): 10097–10104.

[Web of Science®](#)  | [Google Scholar](#) 

Ritthof, O., R. Klinkenberg, S. Fischer, and I. Mierswa. 2002. A hybrid approach to feature selection and generation using an evolutionary algorithm. *In* U.K. Workshop on Computational Intelligence, Birmingham, UK, pp. 147–154.

[Google Scholar](#) 

Robnik-Šikonja, Marko, and Igor Kononenko. 2003. Theoretical and empirical analysis of ReliefF and RReliefF. *Mach. Learn.*, 53(1-2): 23–69.

[Web of Science®](#)  | [Google Scholar](#) 

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

Shen, W., X. Guo, C. Wu, and D. Wu. 2011. Forecasting stock indices using radial basis function neural networks optimized by artificial fish swarm algorithm. *Knowledge-Based Systems*, 24(3): 378–385.

[Web of Science®](#) | [Google Scholar](#)

Sipser, M. 1997. Context-free grammars. *In Introduction to the Theory of Computation*. Edited by M. Lee. PWS Publishing: Boston, pp. 91–122.

[Google Scholar](#)

Tay, F. E. H., and L. Cao. 2001. Application of support vector machines in financial time-series forecasting. *Omega*, 29(4): 309–317.

[Web of Science®](#) | [Google Scholar](#)

Tsay, R. S. 2005. *Analysis of Financial Time-series*, 543. Wiley-Interscience: Hoboken, NJ.

[Google Scholar](#)

Vapnik, V. 1999. *The Nature of Statistical Learning Theory*. Springer: New York.

[Google Scholar](#)

Yang, J., and V. Honavar. 1998. Feature subset selection using a genetic algorithm. *IEEE Intelligent Systems and Their Applications*, 13(2): 44–49.

[Web of Science®](#) | [Google Scholar](#)

Yu, L., S. Wang, and Lai Kin-Keung. 2005. Mining stock market tendency using GA-based support vector machines. *In Lecture Notes in Computer Science 3828*. Springer: Heidelberg Berlin, pp. 336–345.

[Google Scholar](#)

Zapranis, A. 2006. Testing the random walk hypothesis with neural networks. *In Artificial Neural Networks*

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)

Manage Preferences

Accept All

Reject Non-Essential

ABOUT WILEY ONLINE LIBRARY

Privacy Policy

Terms of Use

About Cookies

Manage Cookies

Accessibility

Wiley Research DE&I Statement and Publishing Policies

HELP & SUPPORT

Contact Us

Training and Support

DMCA & Reporting Piracy

Sitemap

OPPORTUNITIES

Subscription Agents

Advertisers & Corporate Partners

CONNECT WITH WILEY

The Wiley Network

Wiley Press Room

Copyright © 1999-2026 John Wiley & Sons, Inc or related companies. All rights reserved, including rights for text and data mining and training of artificial intelligence technologies or similar technologies.

WILEY

This website utilizes technologies such as cookies to enable essential site functionality, as well as for analytics, personalization, and targeted advertising. You may change your settings at any time or accept the default settings. You may close this banner to continue with only essential cookies. [Privacy Policy](#)



Manage Preferences

Accept All

Reject Non-Essential