Use of Neural Networks to Predict Coffee Rust

@LauraKahn | thedatalass.com/coffeeRust/ lkahn@indiana.edu

**Abstract**  
Coffee is the most valuable (monetary) agriculture product in the world and second only to oil in trade with about $100 billion in volume traded annually. Coffee rust infestation leads to production losses of over $1 billion annually worldwide and is caused by Hemileia vastatrix fungus at temperatures between 15-28°C. The livelihood of at least 120 million people worldwide depends on the coffee supply chain. Artificial neural networks can predict coffee rust using temperature, rainfall, production and futures historical data.   
 **Methods**

A multi-layer perceptron (MLP) artificial neural network with 5 layers, 6 neurons, and a hyperbolic tangent activation function was chosen to compensate for the imprecise dataset’s non-linearity and for optimization ease.

**Data Acquisition & Exploration**  
  
Over 1580 weekly observations of Temperature, Rainfall, Production, and Futures data from the Minais Gerais coffee-growing region of Brazil (Köppen-Geiger Cwa Humid subtropical climate) were acquired from January 1993 - July 2018. Rust data was manually obtained from PDF figures and tables in [Chalfoun](https://drive.google.com/file/d/11ecpiEQIYmbn4znbM4bcVMyGOrSWjQWg/view?usp=sharing), Matiello, [Lopes](https://drive.google.com/open?id=1YAexT8zbNqx_5wHIYcu16BJAd8ZM23ZV) andJapiassu since there was no known digital rust data. Temperature and rain data were scraped from the [World Bank Climate Change Knowledge Portal](http://sdwebx.worldbank.org/climateportal/index.cfm?page=downscaled_data_download&amp;menu=historical). Production (supply) data was obtained from the [International Coffee Organization](http://www.ico.org/new_historical.asp?section=Statistics). Historical futures data was available from [macrotrends.net](https://www.macrotrends.net/2535/coffee-prices-historical-chart-data).

Temperature, Rainfall, Production and Futures covariates were used to predict rust infection each week in the Minais Gerais, Brazil growing region. The model is generalizable to other coffee growing regions with a similar Köppen-Geiger climate such as Mexico and Jamaica. Data acquisition challenges included a small set of covariates and data sparsity. These challenges were overcome by using Beretta’s k-Nearest Neighbor imputation method with the rkN-imputer and sk-rebate libraries to fill in 48.8% of missing rust values (773). Missing data was assumed to be missing at random. Matplotlib and Seaborn libraries were used for exploratory data analysis and visualizations.

**Results**

The Mean Squared Error (MSE) for the MLP ANN model performed 131 times better (54.41) than the Logistic Regression model (6619.777) or Decision Tree Regression model (6179.333).

Use of Neural Networks to Predict Coffee Rust

@LauraKahn | thedatalass.com/coffeeRust/ lkahn@indiana.edu

**Conclusion**

Artificial neural networks can be applied in the agricultural commodities field to predict with a fair amount of certainty the weekly coffee Rust percentages in a Humid Subtropical coffee-growing region using historical Rain, Temperature, Production and Futures covariates.

Beretta and Santaniello *BMC Medical Informatics and Decision Making* 2016, **16**(Suppl 3):74 DOI 10.1186/s12911-016-0318-z.

Chalfoun, S. M; Carvalho, V.L, Pereira, M.C. Efeito de alterações climáticas sobre o progresso da ferrugem (Hemileia vastatrix BERK. & BR.) do cafeeiro (Coffea arabica L.). Ciência e Agrotecnologia, Lavras, v. 25, n. 5, p. 1248-1252, September/October. 2001.  
  
Coffee Prices - 45 Year Historical Chart. <https://www.macrotrends.net/2535/coffee-prices-historical-chart-data>. Accessed 1 January 2019.  
  
International Coffee Organization. Historical Data on the Global Coffee Trade. <http://www.ico.org/new_historical.asp?section=Statistics>. Accessed 1 December 2018.

Japiassu, L.B., Garcia, A.W.R., Miguel, A.W., Mononca, J.M.A. Influência da Carga Pendente, Do Espaçamento e De Fatores Climáticos No Desenvolvimento Da Ferrugem Do Cafeeiro. Estação De Avisos Fitossanitários Do Mapa/Fundação Procafé, Varginha, MG. 1998 a 2004.

Lopes, P.R., Ferraz, J.M.G., Theooro, V.C.A., Lopes, I.M. Evolução da ferrugem (Hemileia vastatrix) e da cercosporiose (Cercospora coffeicola) em agroecossistemas cafeeiros convencional, organo-mineral e organico. Revista brasileira de agroecologia. v. 1, n. 7, p. 160-198, 2012.  
  
Matiello, J.B. Controle da ferrugem tardia do cafeeiro exige mudanças de conceitos. <https://bitlylink.com/9sQz7>

World Bank Climate Change Knowledge Portal. <https://climateknowledgeportal.worldbank.org/>