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# Feature-based Time Series Forecasting

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13 March 2019

# Joint work with

# Introduction

# Big picture of the problem

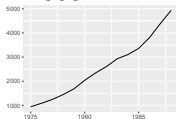
# Time series features

- Transform a given time series  $y = \{y_1, y_2, \dots, y_n\}$  to a feature vector  $F = (f_1(y), f_2(y), \dots, f_p(y))'$ .

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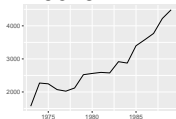
**N0001**



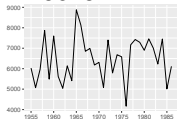
**N0633**



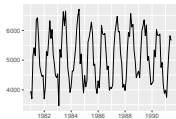
**N0625**



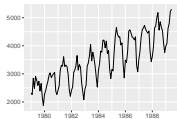
**N0645**



**N1912**



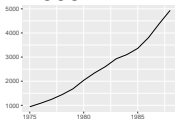
**N2012**



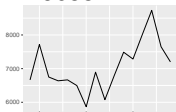
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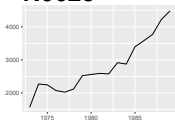
**N0001**



**N0633**



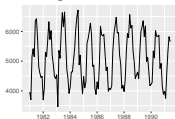
**N0625**



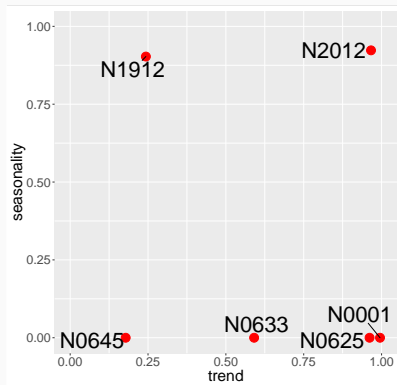
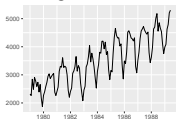
**N0645**



**N1912**



**N2012**

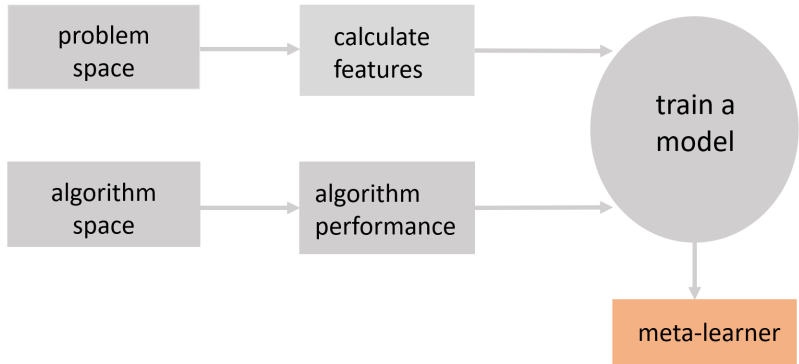


# Features used to select a forecasting model

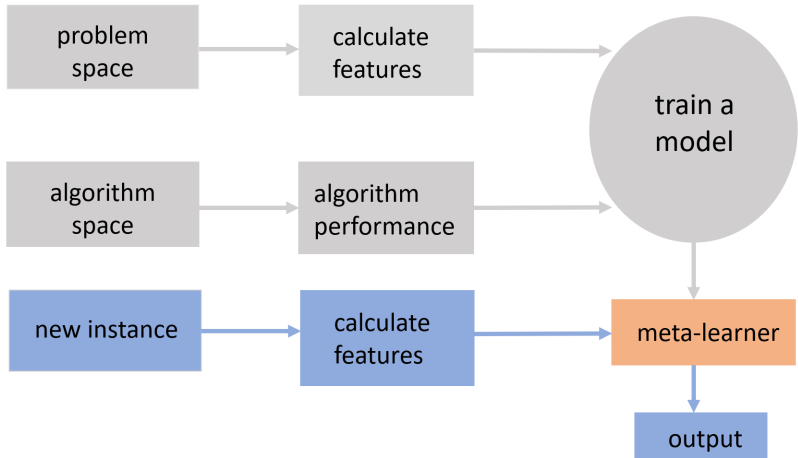
- length
- strength of seasonality
- strength of trend
- linearity
- curvature
- spikiness
- stability
- lumpiness
- parameter estimates of Holt's linear trend method
- spectral entropy
- Hurst exponent
- nonlinearity
- parameter estimates of Holt-Winters' additive method
- unit root test statistics
- crossing points, flat spots
- peaks, troughs
- ACF and PACF based features - calculated on raw, differenced, and remainder series.
- ARCH/GARCH statistics and ACF of squared series and residuals.



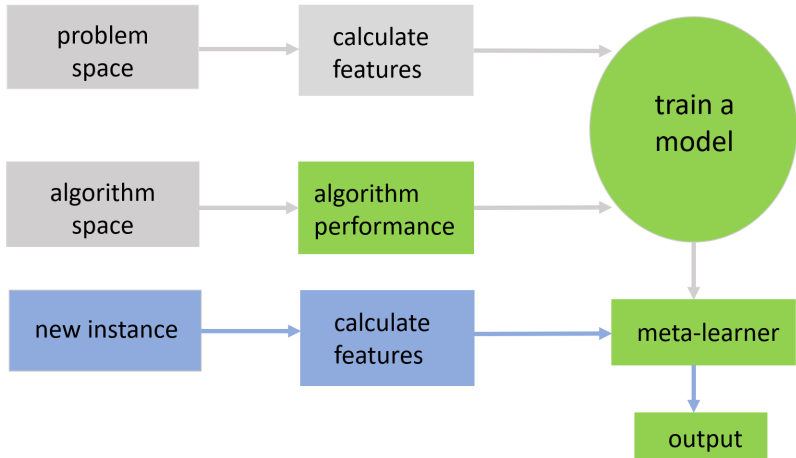
# Meta-learning



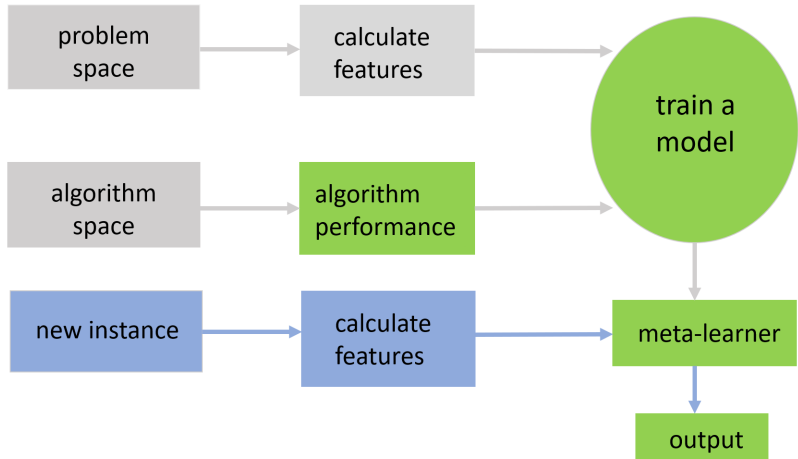
# Meta-learning



# Feature-based forecasting algorithms



# Feature-based forecasting algorithms



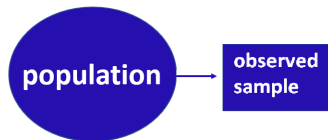
■ three algorithms: **FFORMS**, **FFORMA**, **FFORMPP**

# FFORMS: Feature-based FORecast Model Selection

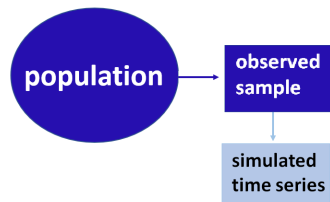


population

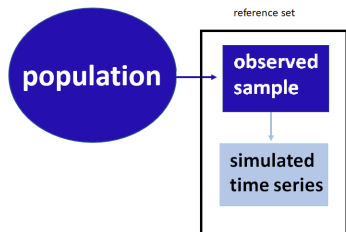
# FFORMS: observed sample



# FFORMS: simulated time series

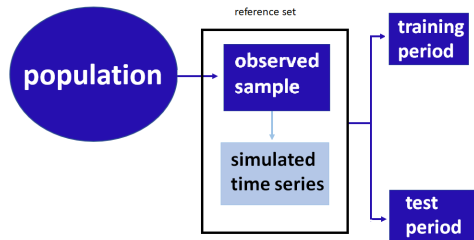


# FFORMS: reference set

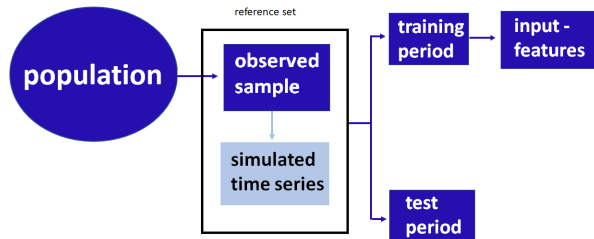




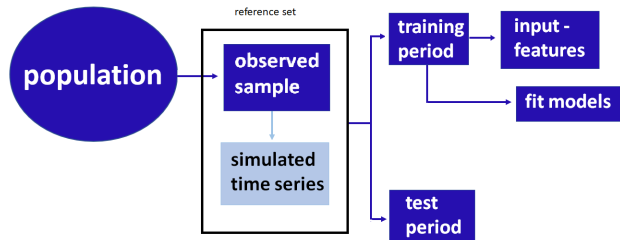
# FFORMS: Meta-data



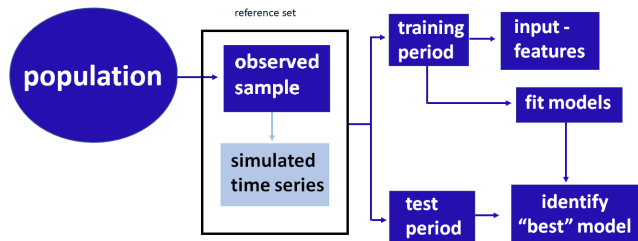
# FFORMS: Meta-data



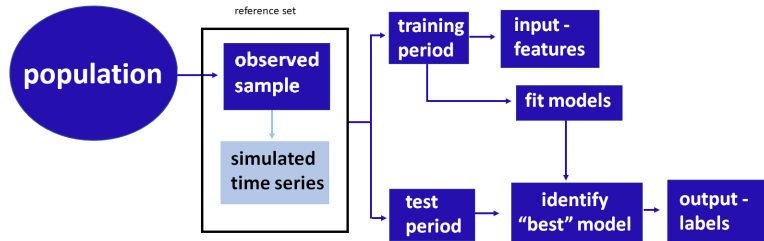
# FFORMS: Meta-data



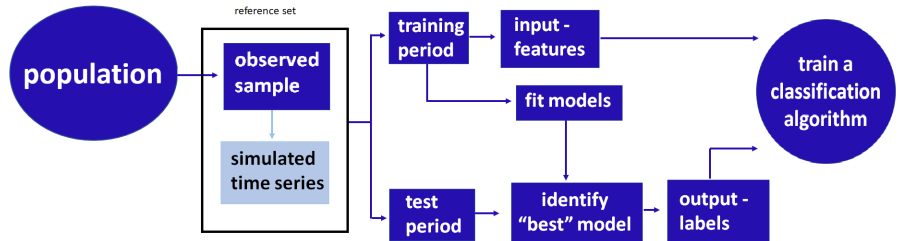
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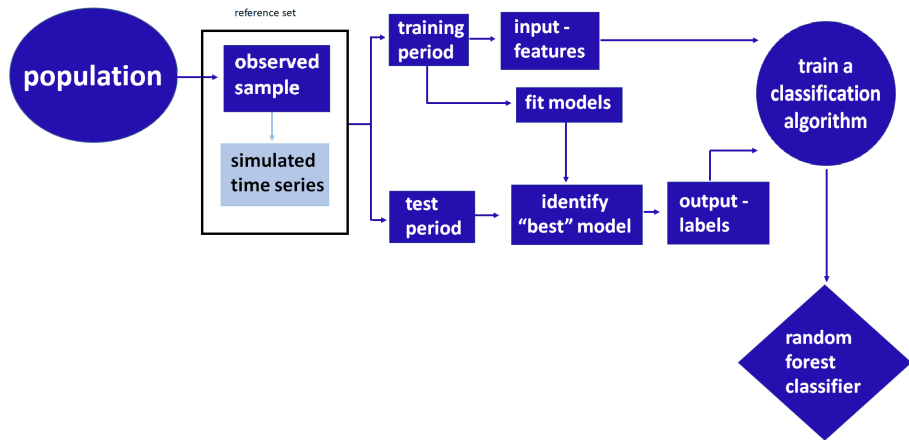
# FFORMS: Meta-data



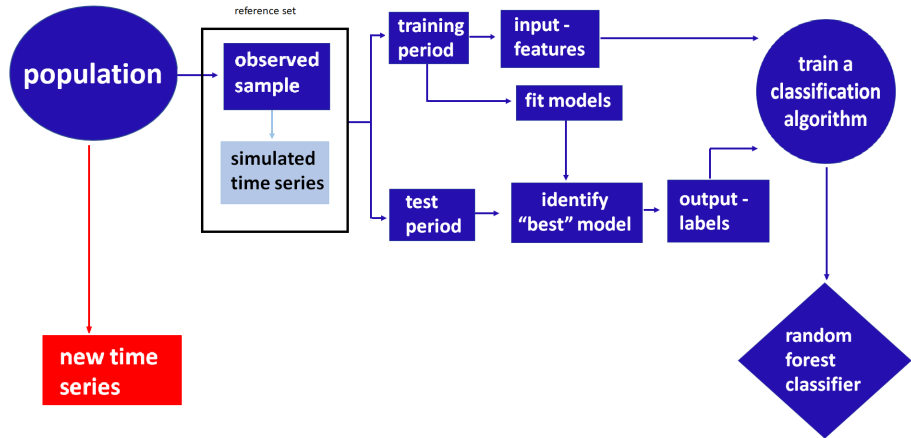
# FFORMS: Meta-data



# FFORMS: Random-forest classifier

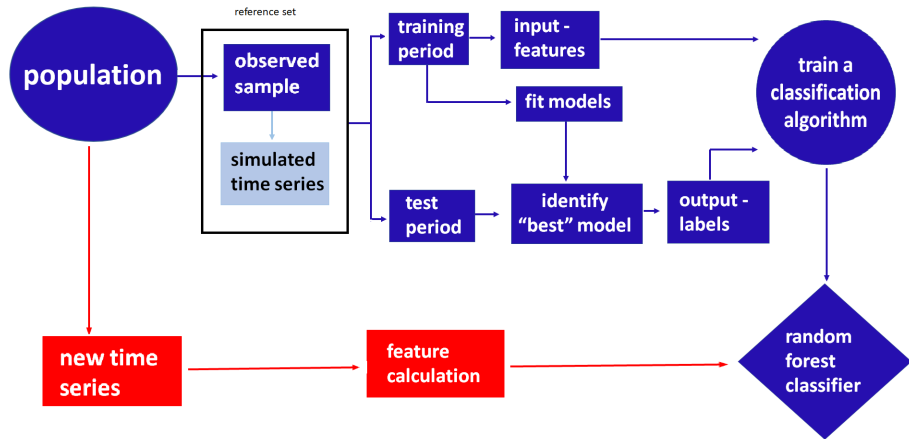


# FFORMS: “online” part of the algorithm

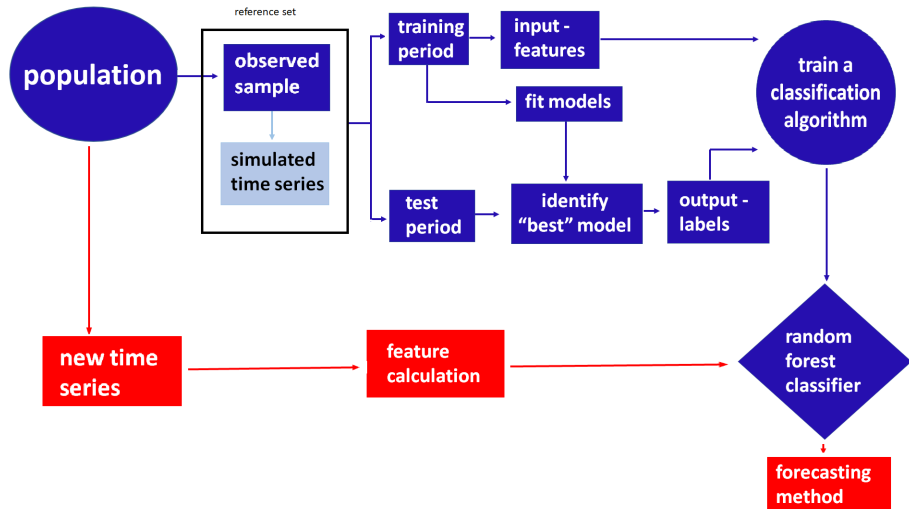




# FFORMS: “online” part of the algorithm



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# Peeking inside FFORMS

# Feature-based FOfRecast Model Averaging

# Feature-based FOfRecast Model Performance Prediction

# R packages

# References