MA5770 – Modelling Workshop Presentation

Topic : Time Series Techniques in Industry
(Project Proposal – A case study approach)

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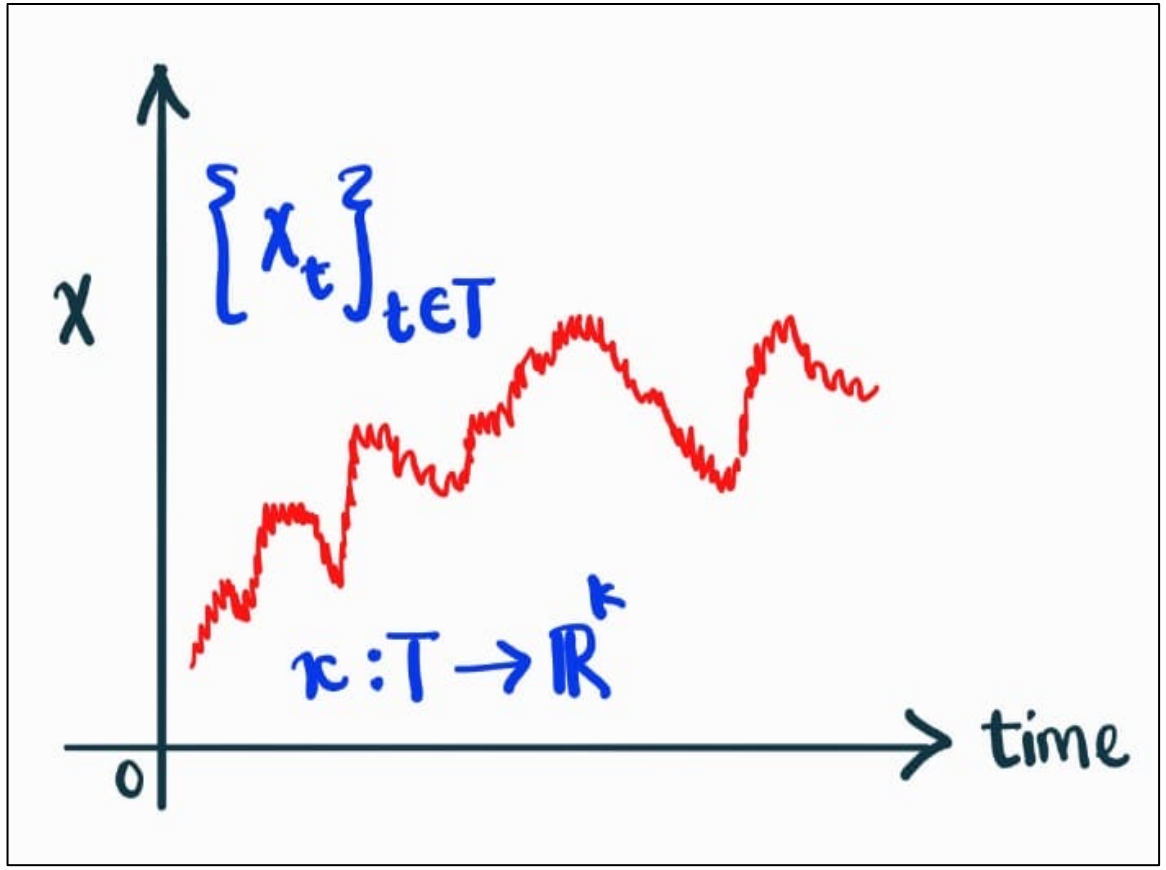
What is a Time Series ?

A data set where the data points are chronologically ordered. (Informally)



Definition 1: (Function mapping)

$$x : T \to \mathbb{R}^k, t \to x_t$$

$$\{x_t | x_t \in \mathbb{R}^k, t \in T\}$$

$$k \in \mathbb{N}, T \subseteq \mathbb{R}.$$

Definition 2: (Sequence of a stochastic process)

$$\{X_t | X_t \in \mathbb{R}^k, t \in T\}, \ (X_t)_{t\in T} \sim P$$

Types of time series:

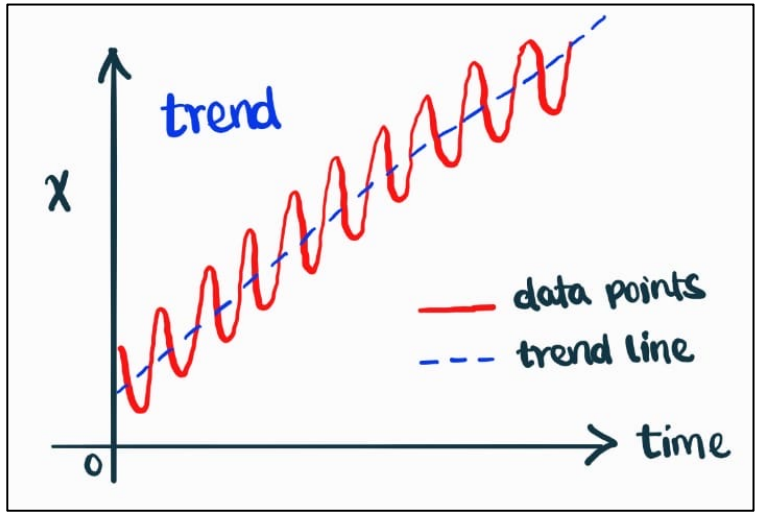
Based on dimensions of x:

- k = 1 → (univariate)
- K ≥ 2 → (multivariate)

Based on time axis T:

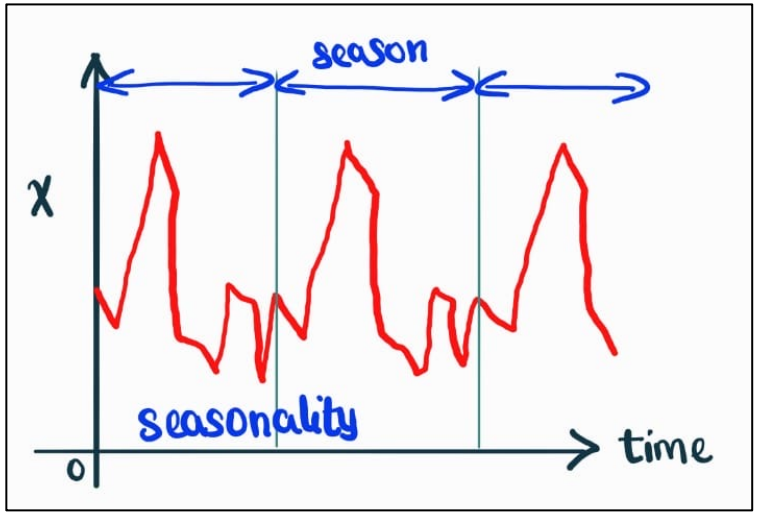
- Discrete
- Continuous

Components of a Time Series



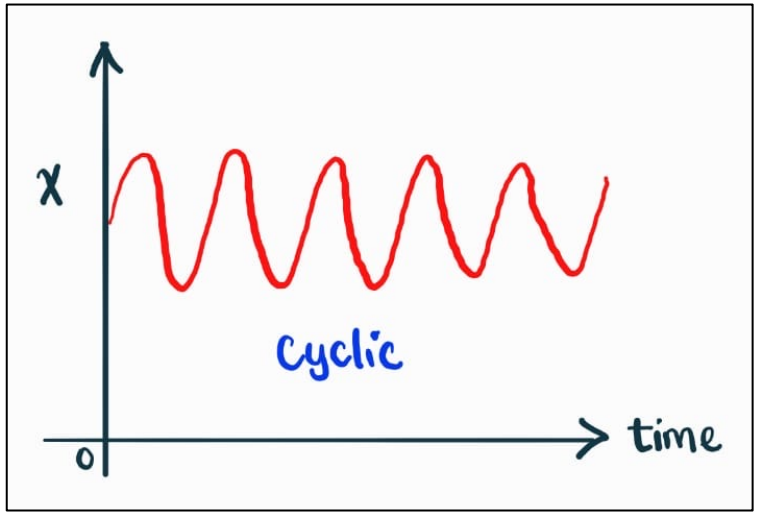
Trend line:

- Long term increase or decrease of the sequence.
- Linear (or) non-linear trend.



Seasonality:

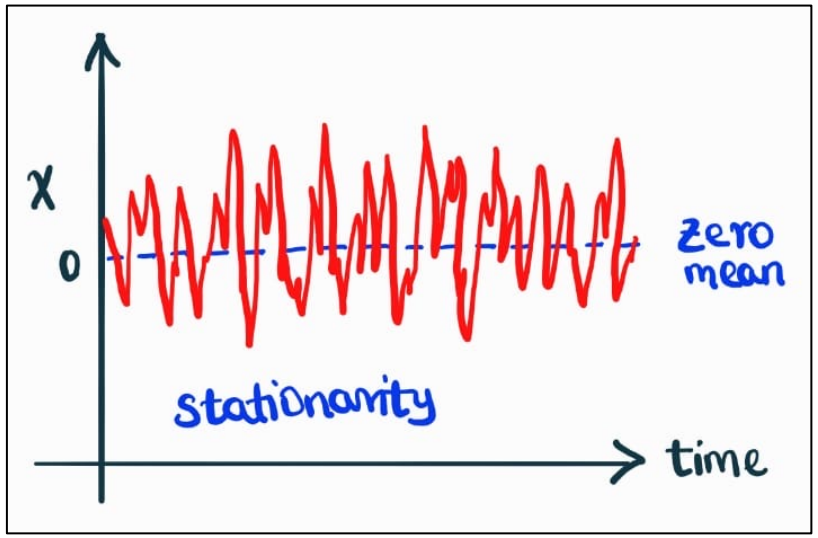
- Repetitive and period variations in a time series.
- Occurs at specific regular intervals of less than a year.

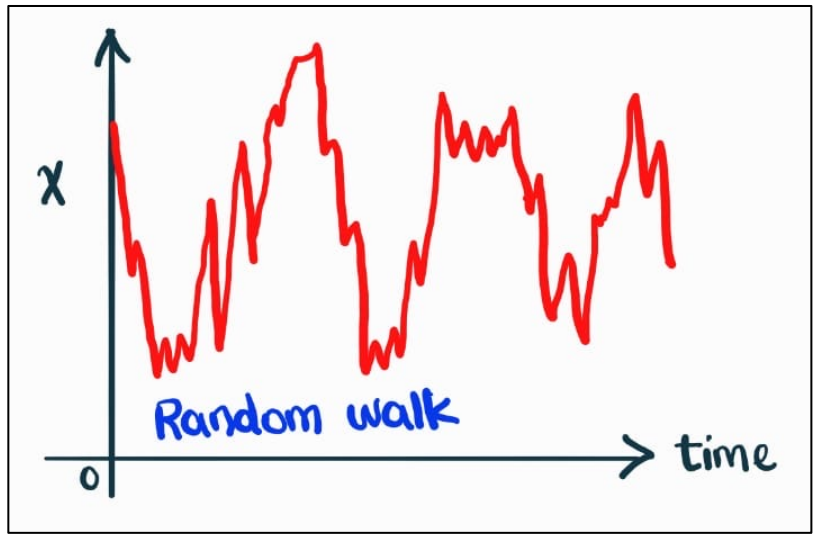


Cyclic movements:

- Rises and falls in the sequence.
- No fixed period of variation.
- Modelled as harmonic regression.

Components of a Time Series (Irreducible error)





Stationary Series :

- Short term fluctuation part of time series.
- Weak stationarity definition
  - Statistics of a dataset remain constant over time.
  - Mean, Variance and Autocorrelation are constant.
  - No predictable trends and seasonality.
- Eg: Zero mean (iid's) normal distribution.

Random walk :

$$S = x_1 + x_2 + \ldots + x_n$$

- Sum of n iids.
- Techniques to stationarise them:
  - First or second order differencing techniques.
  - Transformations (Log, Power).
  - Detrend and Seasonal adjustments.

Time Series Decomposition

Definition: A technique used to break down a time series into its constituent components to better understand and analyse its underlying patterns.

Decomposed into:

- Trend (Linear, non-linear, cyclic).
- Seasonality
- Residue (random noise)

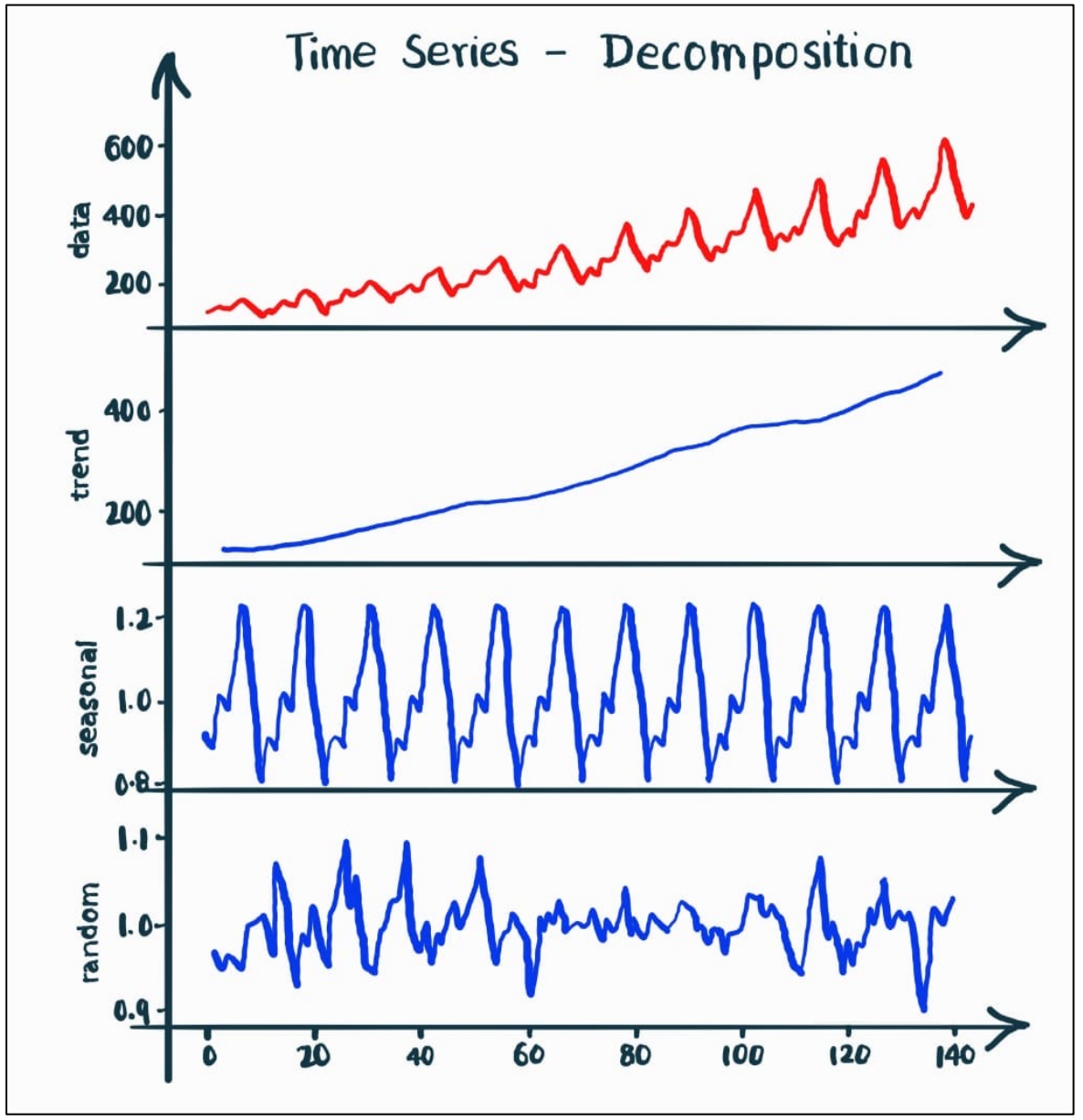
Types of decomposition:

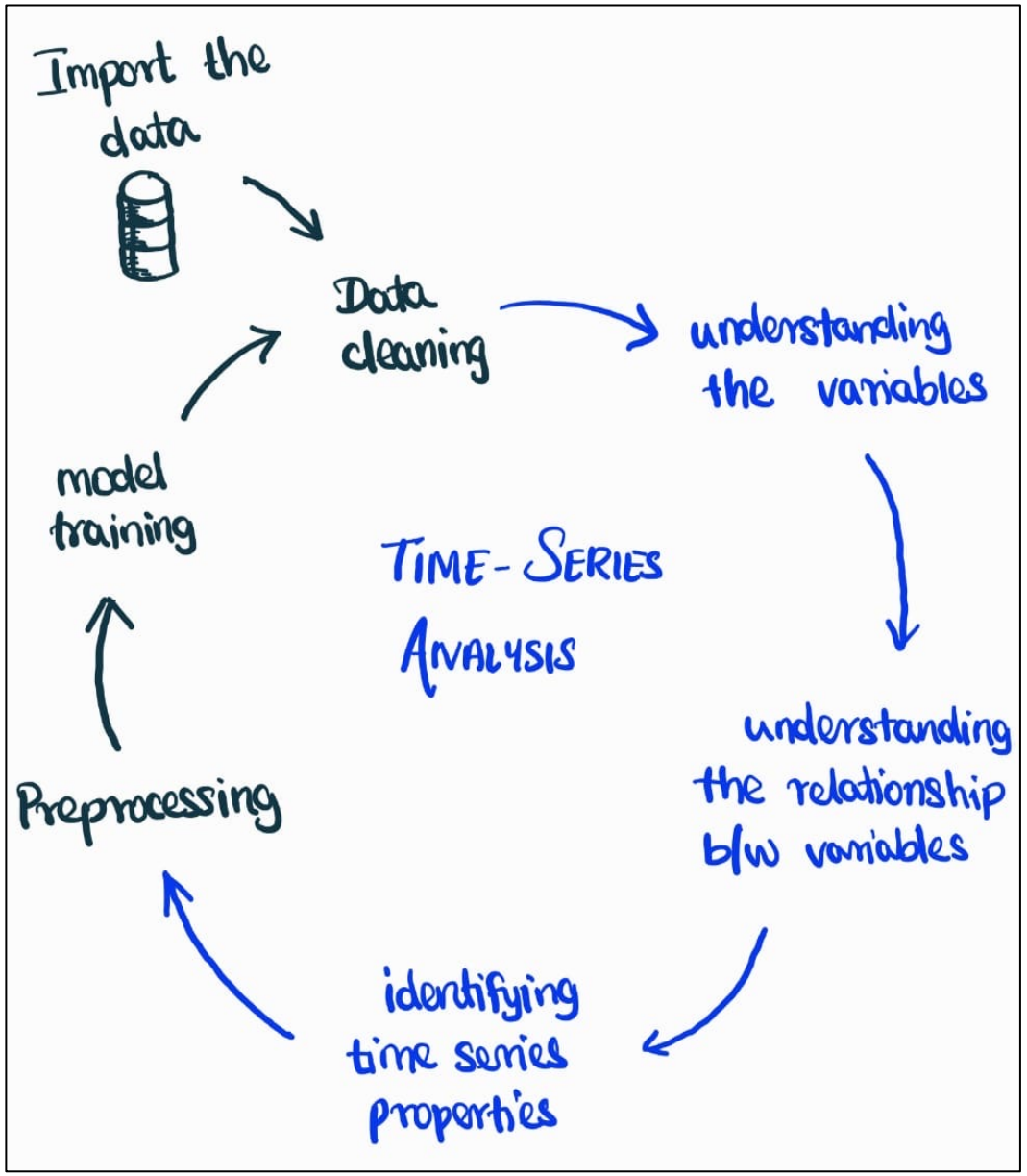
- Additive decomposition

$$x_t = T_t + S_t + R_t$$

- Multiplicative decomposition

$$x_t = T_t \times S_t \times R_t$$





Time Series Analysis

(EDA for time series)

Key steps in Time series analysis :

1. Descriptive statistics for an overview of the dataset.
2. Time plots to visualize trends and anomalies.
3. Seasonal plots and box plots to explore periodicity.
4. Decomposition to break down components.
5. Understand temporal dependencies by,
   - Lag analysis.
   - Autocorrelation and Partial autocorrelation analysis.
6. Stationarity testing to ensure modelling compatibility.
   - Augmented Dickey Fuller test
   - Ljung's Box test, etc,

Time Series Modelling Approaches

① Statistical Models:

(Depends on statistical properties of time series. Eg: stationarity, Autocorrelation.)

- → ARIMA
- → SARIMA
- → Vector Auto Regression (VAR)
- → GARCH
- → State Space Models

② Machine Learning Models:

(Supervised Regression Problem approach)

- → Tree based regressors.
  - Random forest
  - XGi Boost
  - Light Boost
  - Cat Boost
- → Support Vector regressor

③ Deep Learning Models:

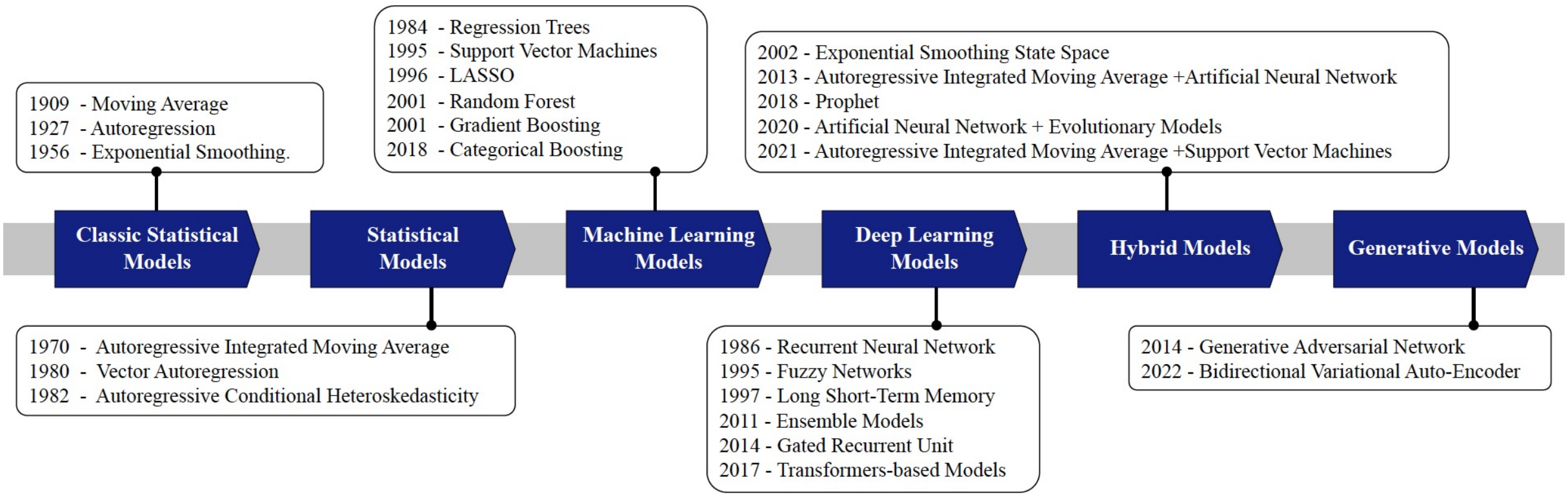
- → ANN
- → RNN
- → LSTM
- → GRU
- → Transformer Models
- → Prophet (Meta)

④ Probabilistic Forecast Models:

(Provides probabilistic outputs)

No point estimates.

- → Gaussian Processes
- → Bayesian Models
- → Deep AR (Amazon)



Other techniques

Parallel - Ensemble Technique :

Core Principles :

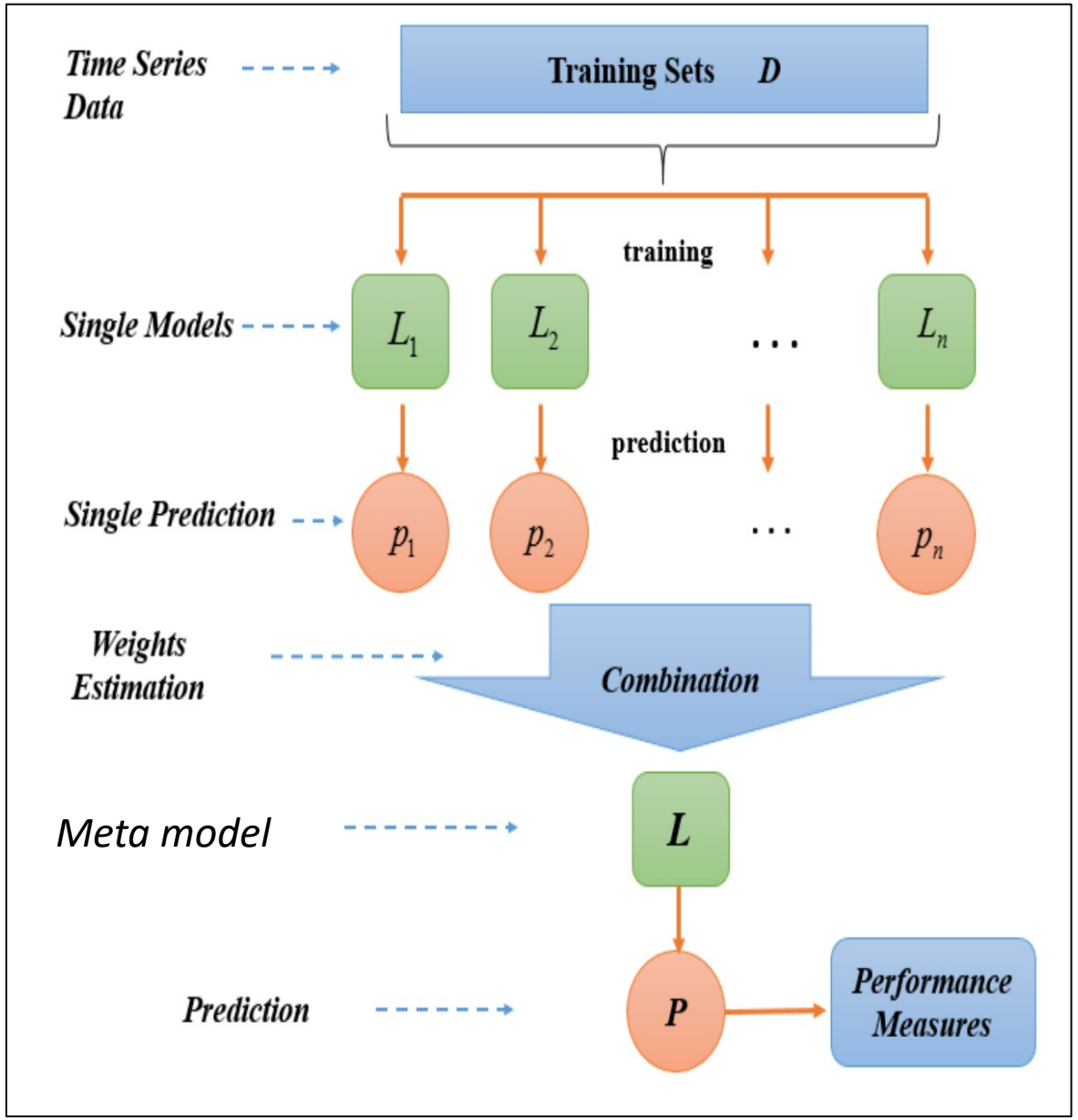
- Independence of Models.
- Diversity of Models.
- Combination of Predictions (Meta model).

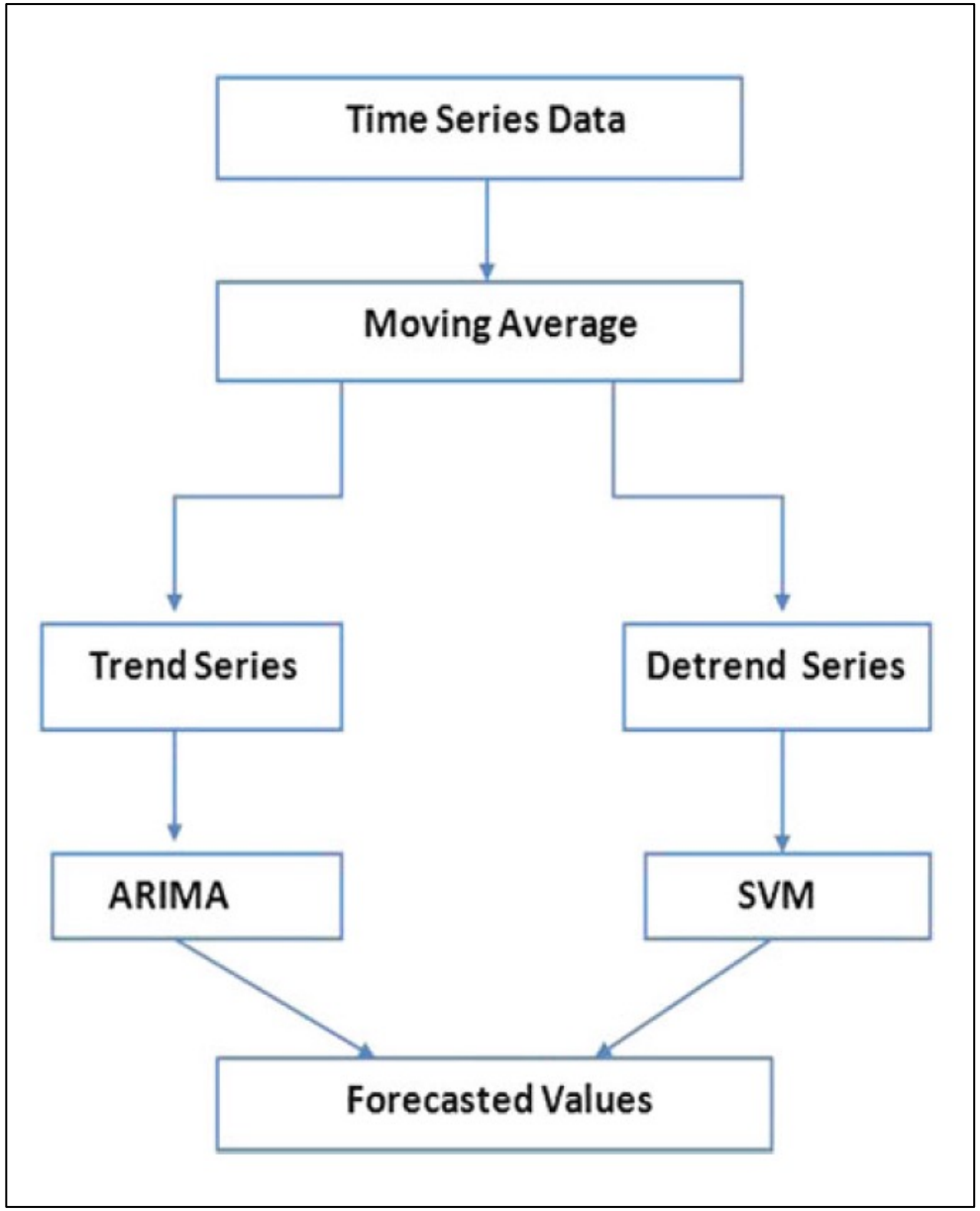
Principle : Bootstrap Aggregation (Bagging).

Advantages : Improved performance and roboustness.

Cons :

- Model Selection.
- Computational cost.
- Hyperparameter tuning.





Other techniques

Hybrid Modelling of Time Series :

1.ARIMA-ML Hybrid:

- Use ARIMA to model linear components.
- Apply ML techniques (e.g., Random Forests) to capture non-linear patterns in residuals.

2.Decomposition-Based Hybrid:

- Decompose the time series.
- Model each component separately by different techniques.
- Combine predictions from all components.

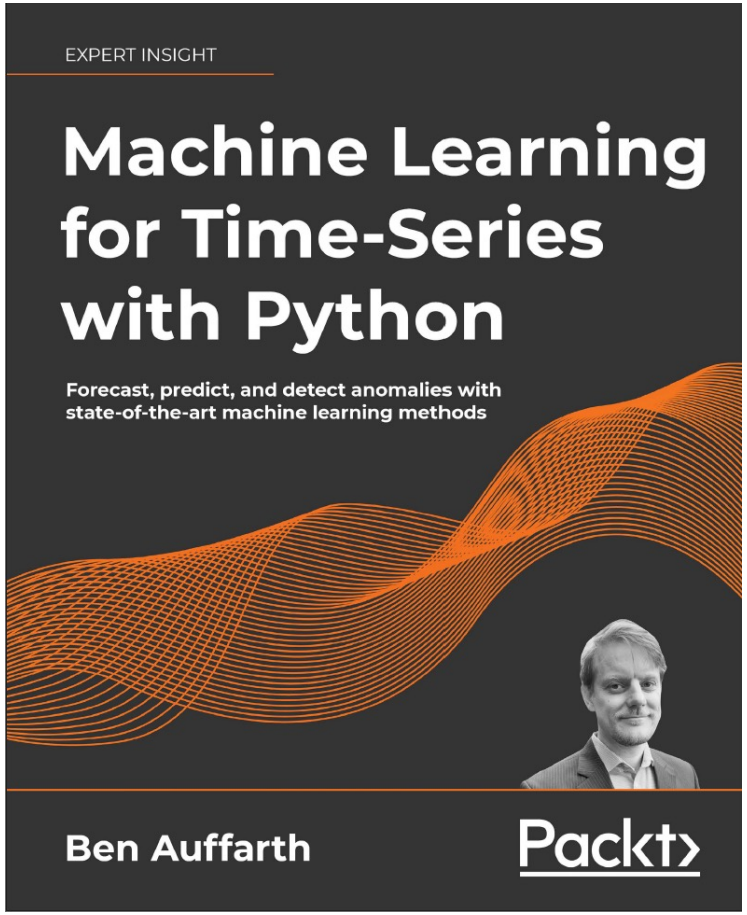
3.Two-Stage Hybrid:

- Use one model to generate initial forecasts.
- Employ a second model to refine these predictions.

Reference Books :

1	Title	Practical Time Series Analysis
	Authors	Avishek Pal, P. K. S. Prakash
	Publisher	Packt Publishing, 2017
2	Title	Applied Time Series Analysis: A Practical Guide to Modeling and Forecasting
	Author	Terence C. Mills
	Publisher	Elsevier, 2019

(Good Beginner book)



THANK YOU!