Time Series Data

Industrial AI Lab.

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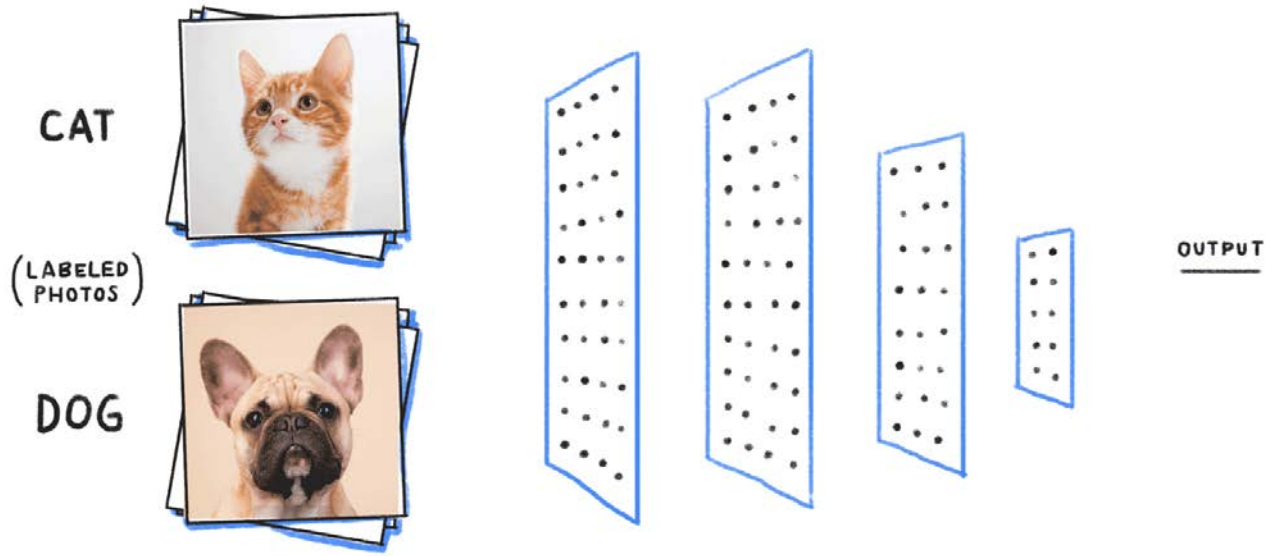
So Far

- Regression, Classification, Dimension Reduction,
- Based on snapshot-type data



Robocup 2011

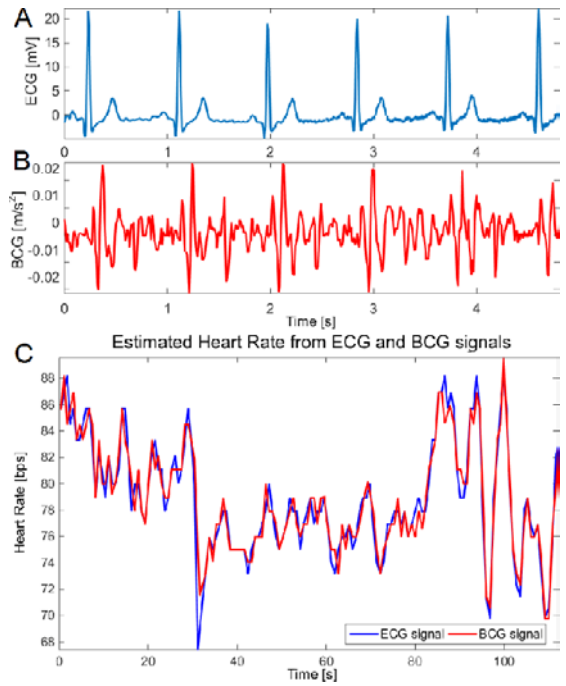
Robocup 2011 Final

Sequence Matters

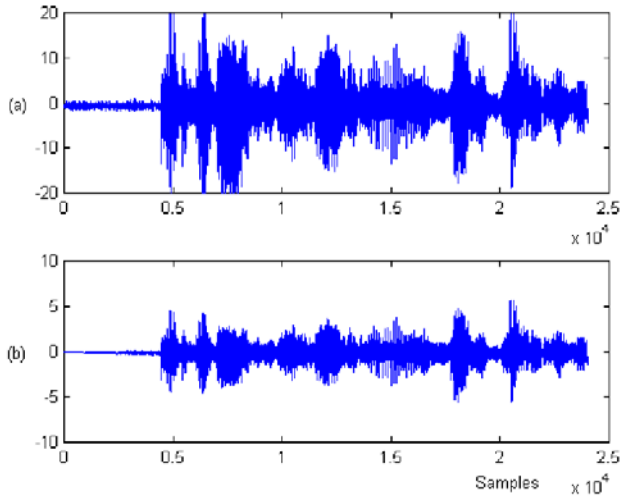
What is a Sequence ?

- Sentence
  - “This morning I took the dog for a walk.”

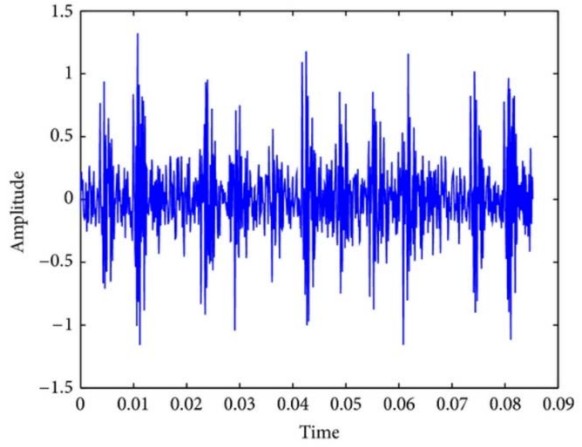
- Medical signals



- Speech waveform



- Vibration measurement



(Deterministic) Time Series Data

- For example

$$y[0] = 1, \quad y[1] = \frac{1}{2}, \quad y[2] = \frac{1}{4}, \quad \cdots$$

- Closed-form

$$y[n] = \left(\frac{1}{2}\right)^n, \quad n \geq 0$$

- Linear difference equation (LDE) and initial condition

$$y[n] = \frac{1}{2}y[n-1], \quad y[0] = 1$$

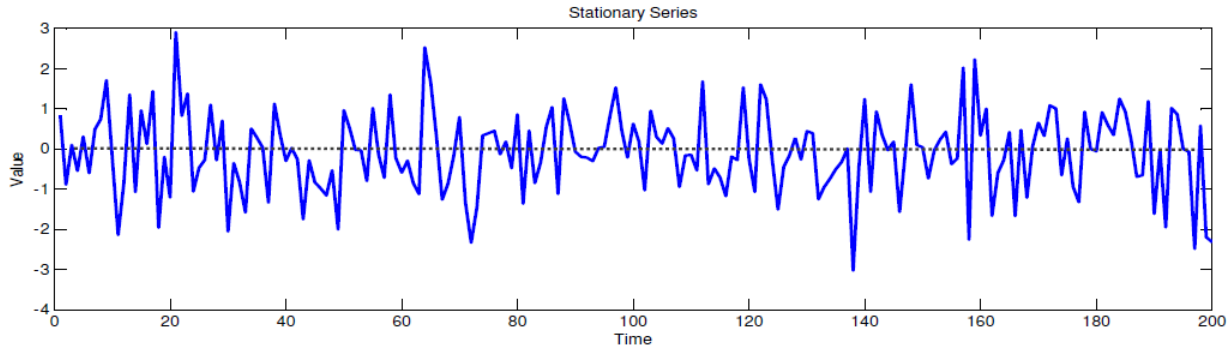
- High order LDEs

$$y[n] = \alpha_1 y[n-1] + \alpha_2 y[n-2]$$

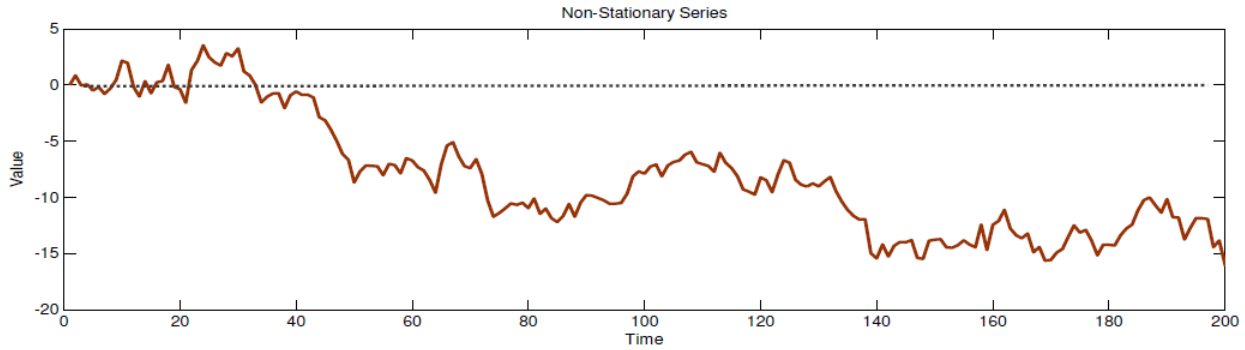
$$y[n] = \alpha_1 y[n-1] + \alpha_2 y[n-2] + \cdots + \alpha_k y[n-k]$$

(Stochastic) Time Series Data

- Stationary

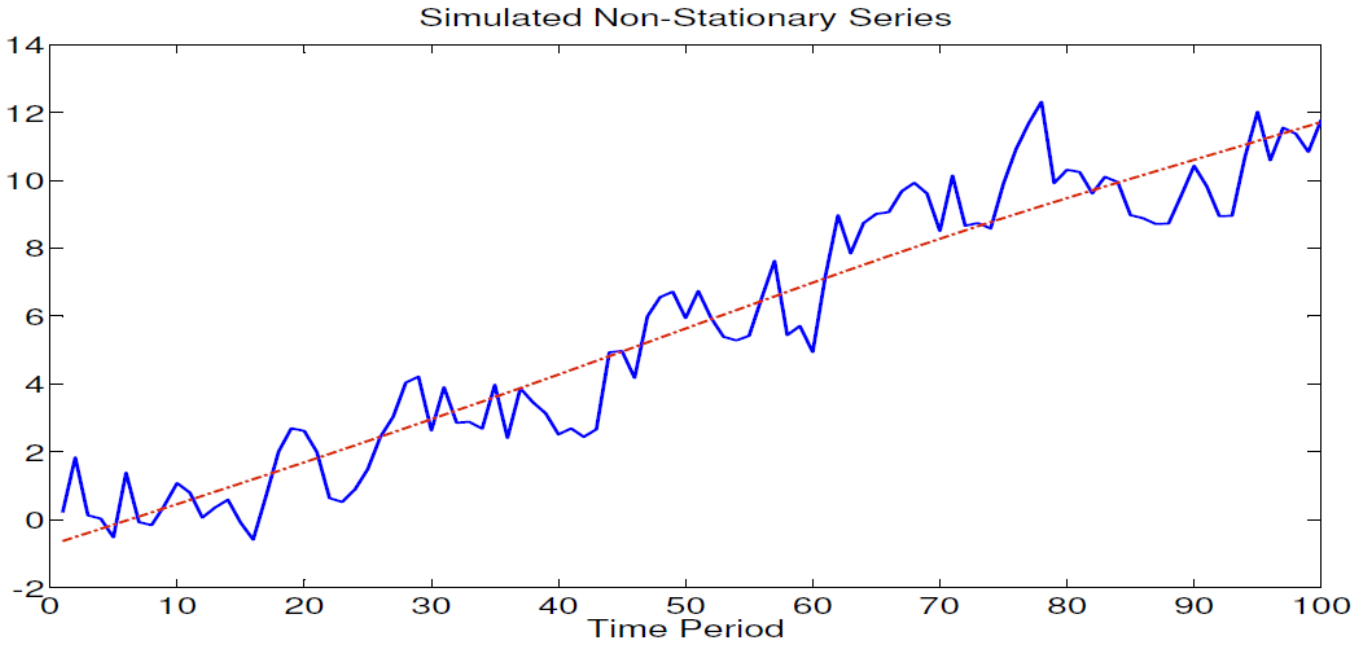


- Non-stationary
  - Mean and variance change over time



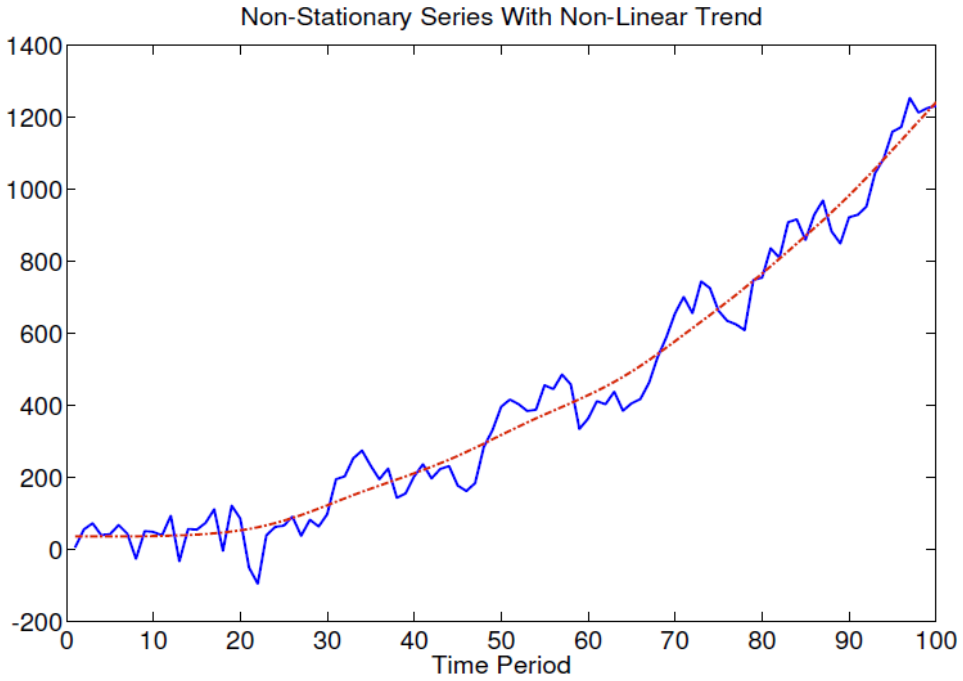
Dealing with Non-Stationarity

- Linear trends



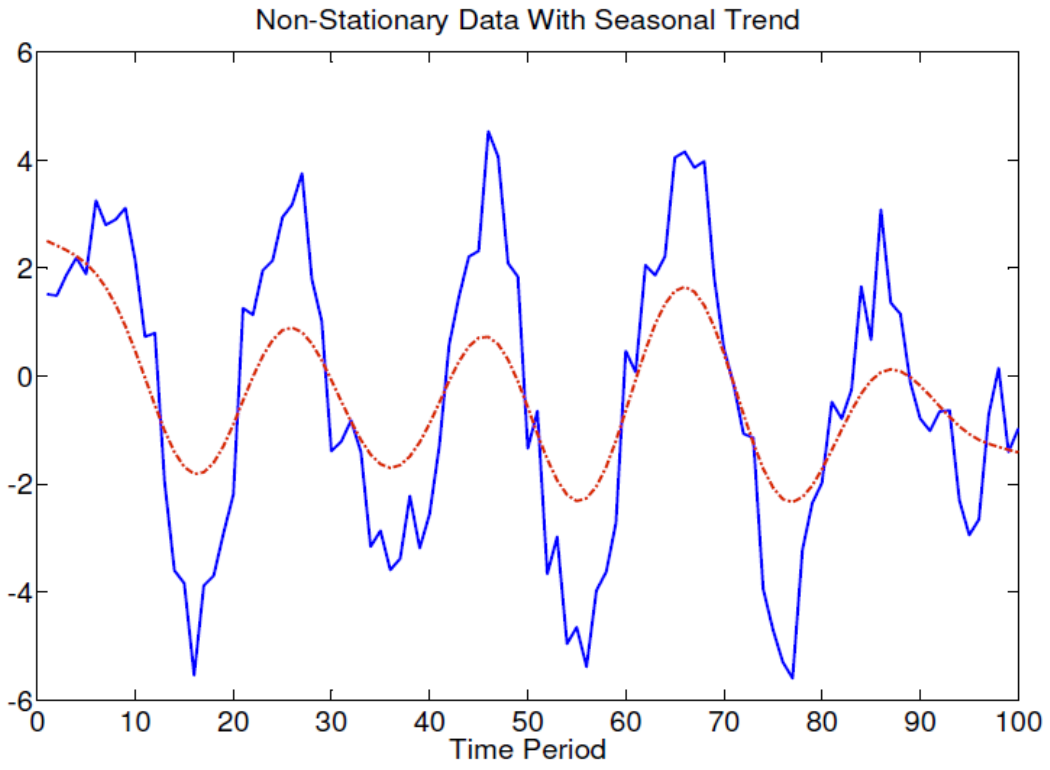
Dealing with Non-Stationarity

- Non-linear trends



Dealing with Non-Stationarity

- Seasonal trends



Dealing with Non-Stationarity

- Model assumption

$$
\begin{aligned}
Y_t = \beta_1 + \beta_2 Y_{t-1} \\
+ \beta_3 t + \beta_4 t^{\beta_5} \\
+ \beta_6 \sin \frac{2\pi}{s} t + \beta_7 \cos \frac{2\pi}{s} t \\
+ u_t
\end{aligned}
$$