Time Series Analysis

Introduction

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Introduction

- What is times series?
- A time series is an ordered sequence of observations.
- This ordering is usually through time.
- In other words, time series is based on observations that are collected sequentially in time.

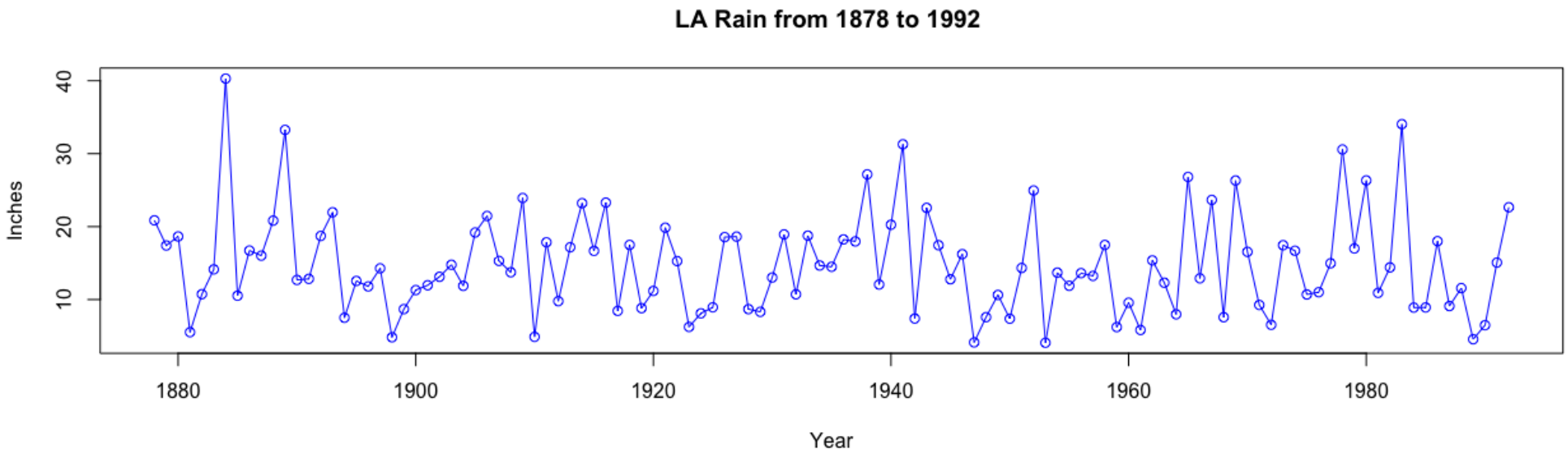
Examples of time series I

- Business and Economics:
  - Stock prices,
  - Weekly interest rate,
  - Monthly price index,
  - Quarterly sales,
  - Yearly earnings and etc
- Meteorology:
  - Hourly wind speed,
  - Daily and monthly Average Air temperature,
  - Annual rain fall and etc.

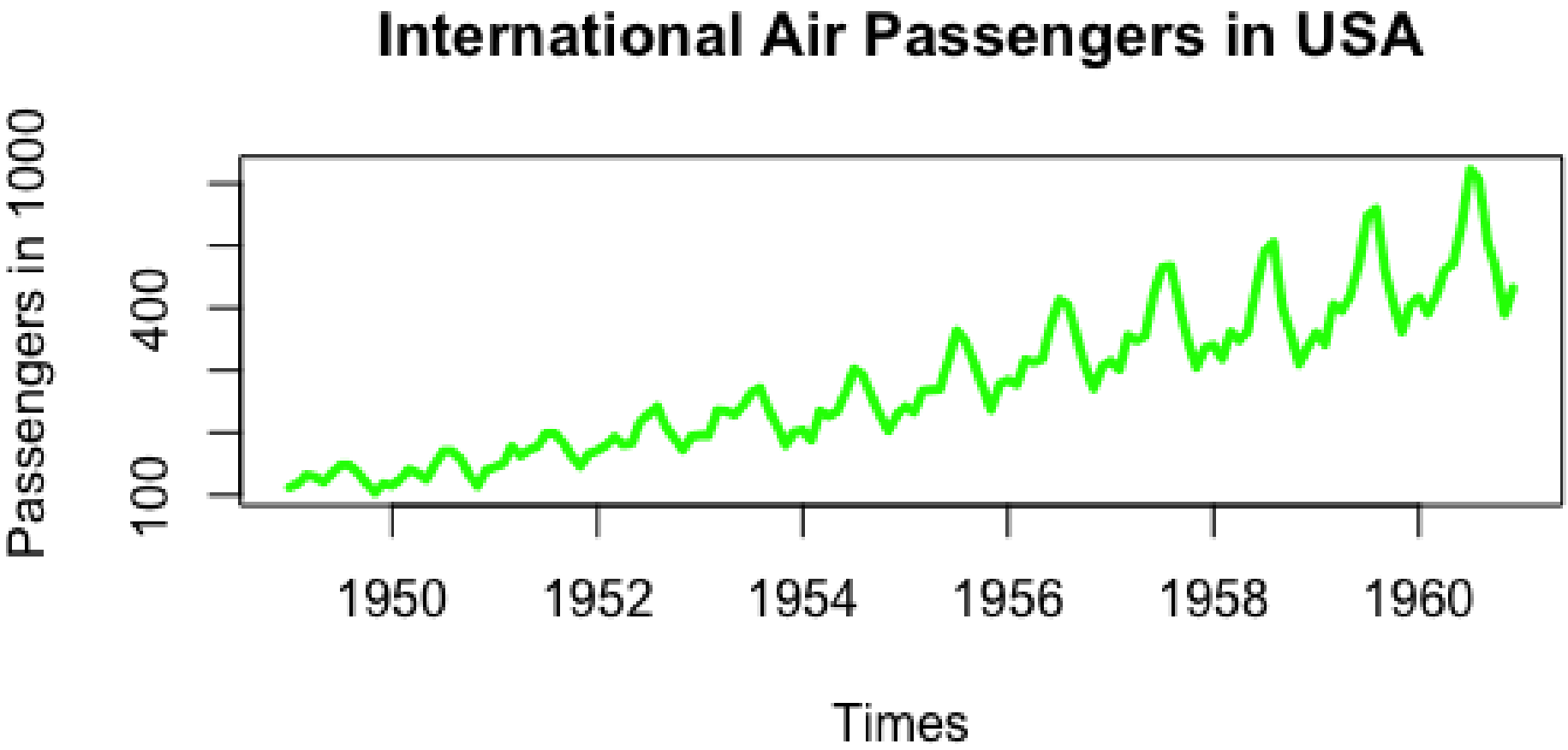
Examples of time series II

- Social Sciences:
  - Births,
  - deaths
  - unemployment,
  - high school dropouts,
  - divorces
  - Population
  - crime, etc;
- We can add to the list, Health Science, Biology, Computer Science, ...

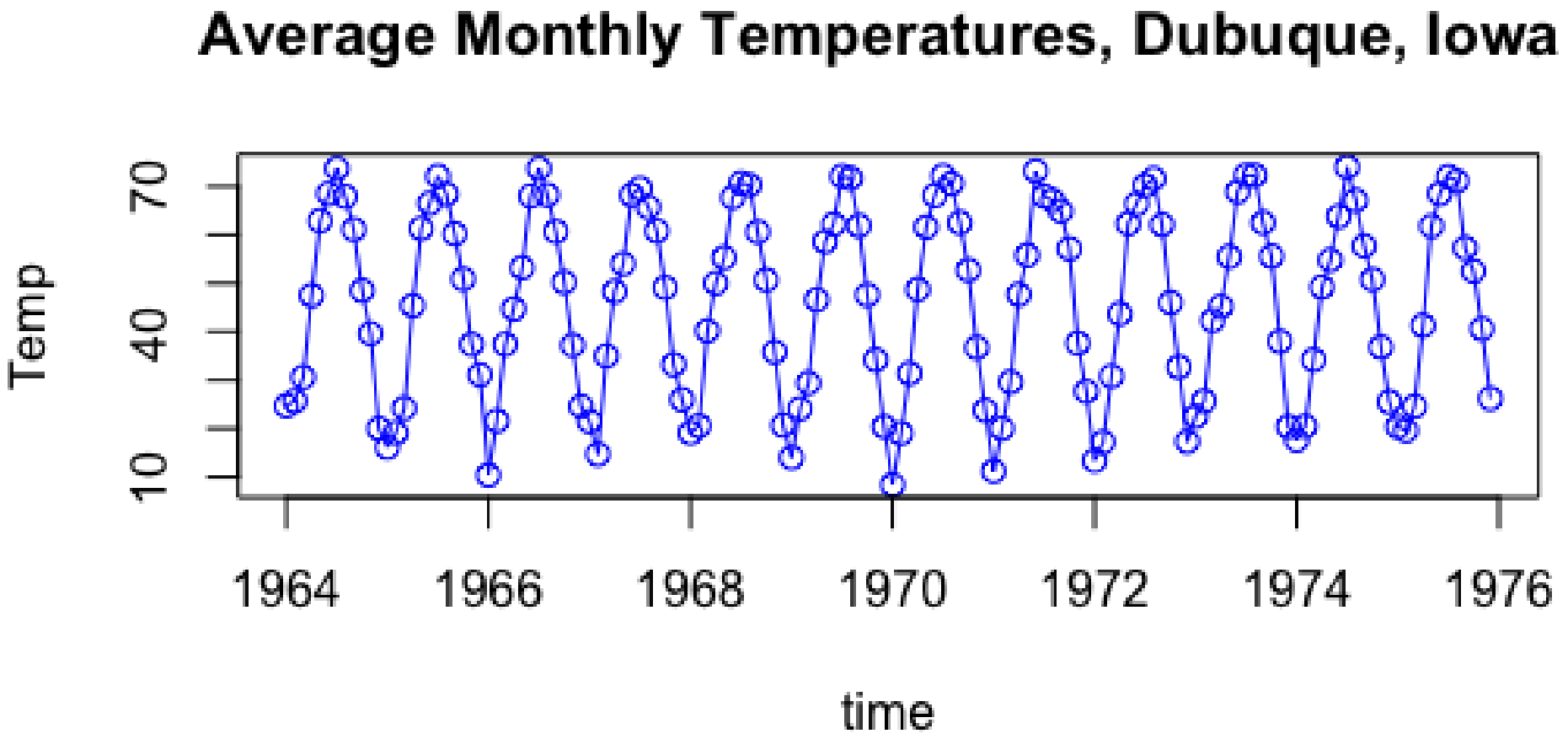
Examples of time series



Examples of time series

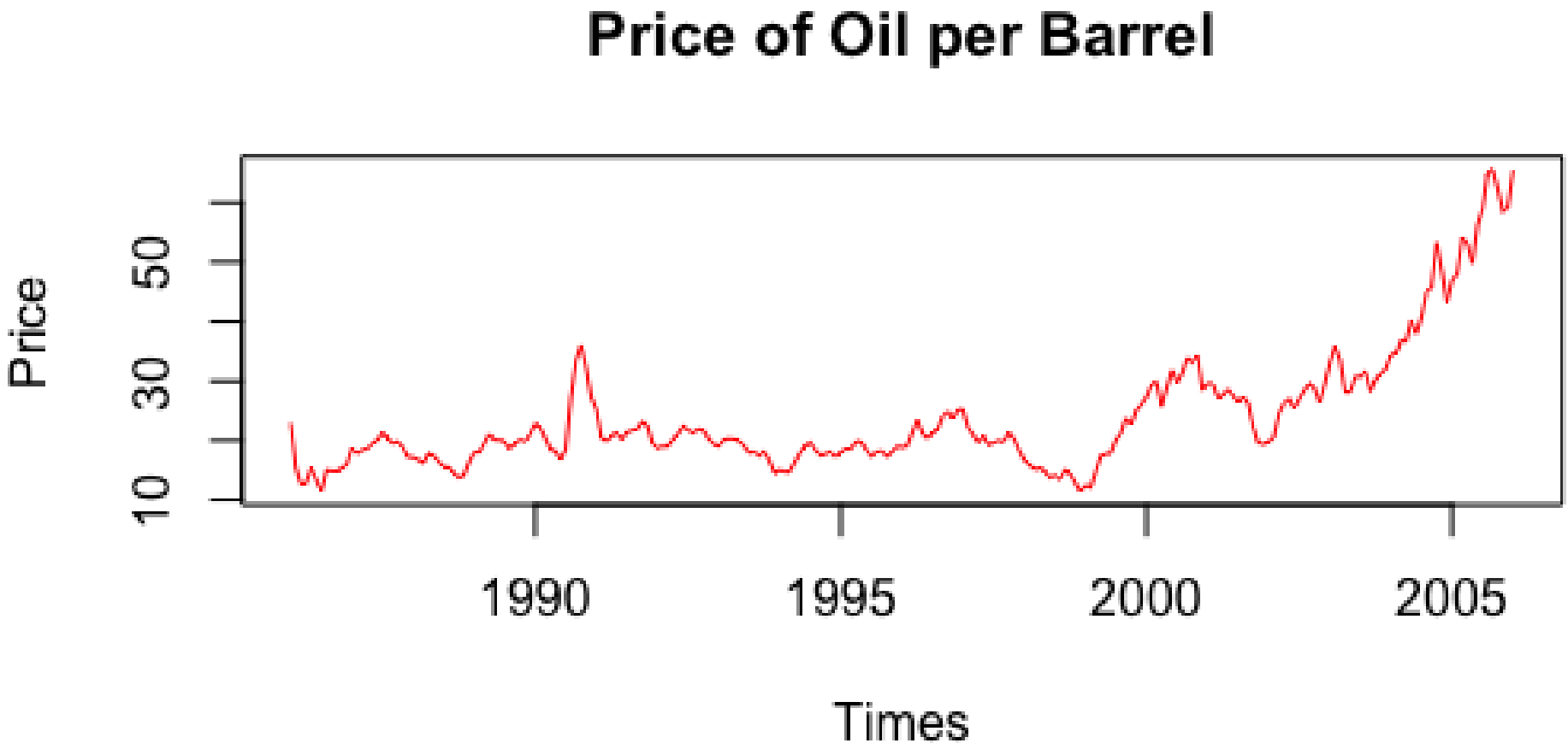


Examples of Time Series



- This time series displays a very regular pattern called seasonality.

Examples of time series



Building Model for Time Series Data

- Finding appropriate models for time series is a nontrivial task.
- We want to follow the “principle of parsimony” in model building.
- The model should require the smallest number of parameters that will adequately represent the time series.
- We need to come up with procedures to estimate the parameters of the model.
- This parameter estimation is often done using Least Squares or Maximum Likelihood methods.

Terminology

- A time series is a collection of variables indexed by a set $T \subset \mathbb{R}$= real line.
- We call the set T the time index, regardless of whether it is physical time.
- A time series is said to be continuous when the time index T is a 'continues' set.
- If the time index T is a 'discrete' set, the time series is said to be discrete.
- A discreet time series is regularly spaced if the observations are taken at equal intervals.
- If a time series can be predicted exactly, it is said to be deterministic otherwise stochastic.

Objectives of Time Series Analysis

- Description
- Explanation
- Prediction
- Control

Description

- This is the first step in time series analysis and is analogous to descriptive statistics in the analysis of ordinary data.
- Descriptive analysis determines what trends and patterns a time series has by plotting or using more complex techniques.
- The most basic approach is to graph the time series and look at:
  - Overall trends (increase, decrease, etc.)
  - Cyclic patterns (seasonal effects, etc.)
  - Outliers - points of data that may be erroneous
  - Turning points - different trends within a data series
  - autocorrelation

Explanation

- To construct and fit a model to explain the time series behavior in terms of other variables.
- Using one or more variable time series, a mechanism that results in a dependent time series can be estimated.
- A common question to be answered with this analysis would be “What relationship is there between two-time series data sets?”
- Example: Atmospheric pressure and seawater temperature affect sea level. All of these data are in time series and can relate to how and to what degree pressure and temperature affect the sea level.

Prediction and Control

- Prediction: if a time series has behaved a certain way in the past, the future behavior can be predicted within certain confidence limits by building models.
- Control: To control the process generating the series by examining what happens to the outcome of the process if certain model parameters were changed.

Approaches to Time Series Analysis

- Analysis in the time domain: helps to describe the evolution of a process through time via one or some of the following approaches
  - Descriptive analysis, including different ways of smoothing and filtering methods
  - Analysis and modeling of the autocorrelation function including SARIMA modeling
  - State space analysis including Kalman filtering

Approaches to Time Series Analysis

- Analysis in the frequency domain: is based on the spectral density (Fourier transform of autocorrelation function)
- Wavelet-based methods are an attempt to model series in both domains.

There is a one-to-one mapping between time domain analysis and spectral analysis.