

Time Series

Emerson Amirhosein Azarbakht

Time Series (TS)

Used in

- control of inventory, based on demand trends
- airline's decision to buy airplanes bc of passenger trends and decision to increase/maintain market share
- climate change decisions based on temperature change trends
- business/sales forecasting
- everyday operational decisions
- long-term effects of proposed water management policies by simulating daily rainfall and sea state time series
- understanding fluctuations in monthly sales
- basis for signal processing in telecommunications <?>
- disease incidence tracking, yearly rates
- census analysis
- tracking monthly unemployment rate; as an economic indicator used by decision makers

Used to

- to understand the past, and predict the future
- forecasting (predicting inference, a subset of statistical inference). assumes that present trends continue. This assumption cannot be checked empirically, but, when we identify the likely causes for a trend, we can justify the forecasting(extrapolating it) for a few time-steps at least
- anomaly detection
- clustering
- classification (assigning a time series pattern to a specific category: e.g. gesture recognition of hand movements in sign language videos)
- query by content ~ Content-based image retrieval

Data: a variable measured sequentially in time, or at a fixed [sampling] interval

serial dependence problem: observations close together in time tend to be correlated (serially dependent)

TS tries to explain this correlation (serial dependence) autocorrelation analysis examines this serial dependence <?>

conditions (assumptions of TS)

- stationary process ?
- Ergodic process ?

```
plot(AirPassengers)
start(AirPassengers)
```

```
## [1] 1949    1
```

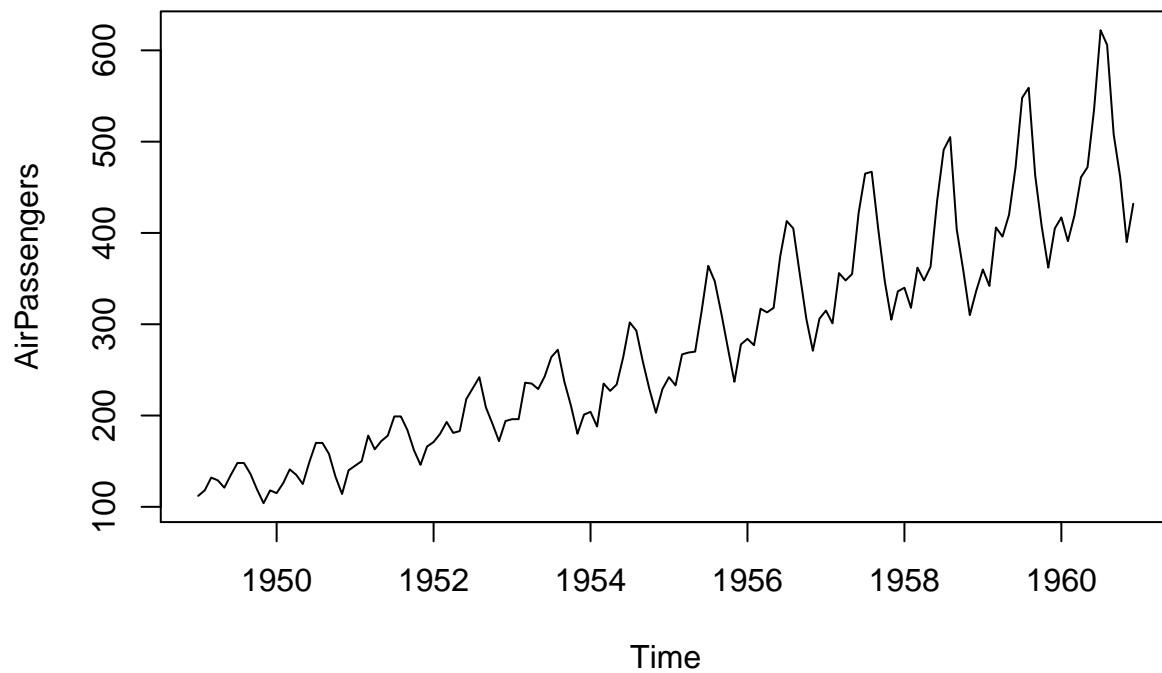
```
end(AirPassengers)
```

```
## [1] 1960   12
```

```
frequency(AirPassengers)
```

```
## [1] 12
```

```
plot(AirPassengers)
```



```
summary(AirPassengers)
```

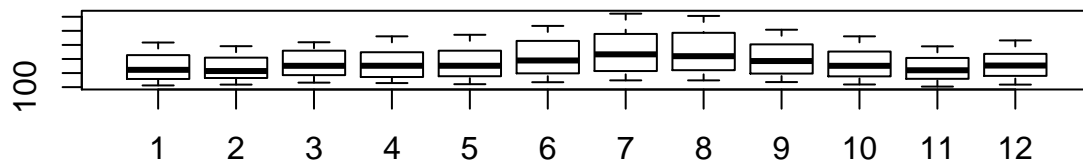
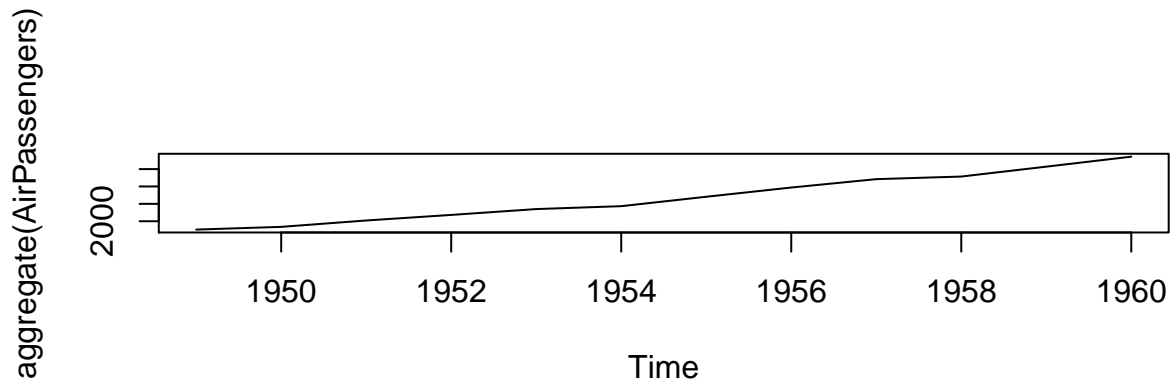
```
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  104.0   180.0   265.5   280.3   360.5   622.0
```

```
layout(1:2)
```

```
# takes an input matrix for the location of each plot in the graphics window
```

```
plot(aggregate(AirPassengers))
```

```
boxplot(AirPassengers ~ cycle(AirPassengers))
```



plotting shows *patterns*, and *features* of the data + *outliers* and *erroneous* values

patterns

1. trend = a non-periodic systematic change in a TS can be modeled simply by a linear increase or decrease
2. seasonal variation = a repeating pattern within a fixed period (e.g. each year)
3. cycles = a non-fixed-period cycle (without a fixed period). example: El-Nino

```
# monthly unemployment rate for the US state of Maine from January 1996 until August 2006
Maine.month <- read.table("http://staff.elena.aut.ac.nz/Paul-Cowpertwait/ts/Maine.dat", header = TRUE)
# header TRUE means treat first row as column names
attach(Maine.month)
str(Maine.month)
```

```
## 'data.frame': 128 obs. of 1 variable:
## $ unemploy: num 6.7 6.7 6.4 5.9 5.2 4.8 4.8 4 4.2 4.4 ...
```

```
head(Maine.month)
```

```
## unemploy
## 1 6.7
## 2 6.7
## 3 6.4
## 4 5.9
## 5 5.2
## 6 4.8
```

```
class(Maine.month)
```

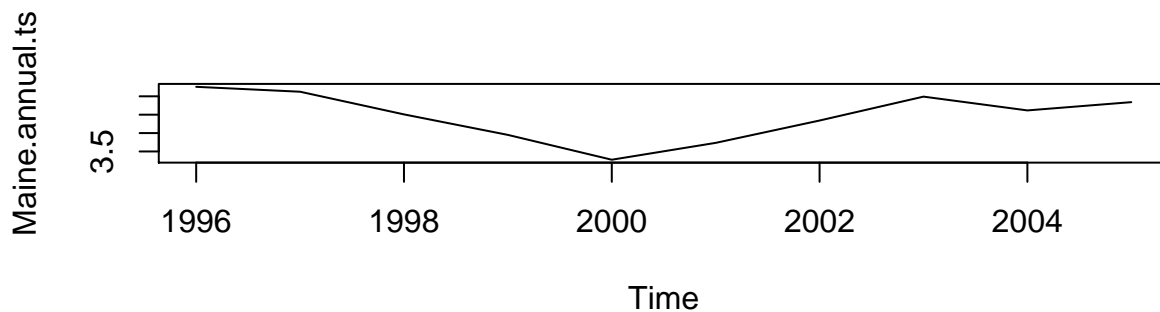
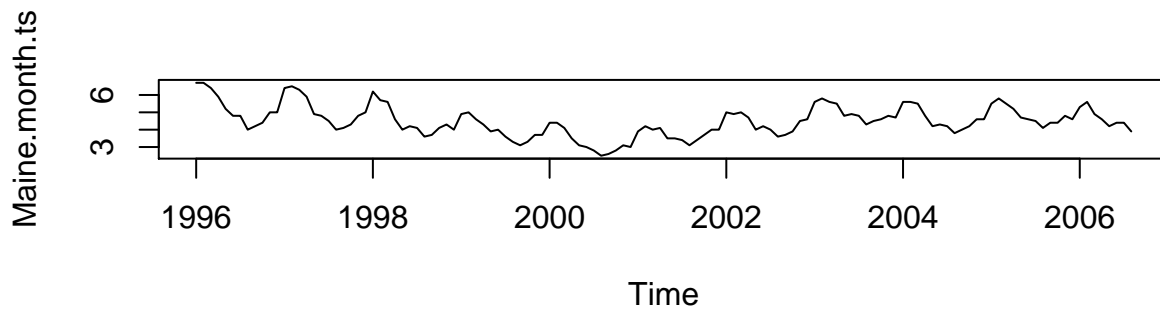
```
## [1] "data.frame"
```

```
# it's a data.frame, not a ts object. So, we need to convert it to ts
```

```
Maine.month.ts <- ts(unemploy, start = c(1996, 1), freq = 12)  
Maine.month.ts
```

```
##      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec  
## 1996 6.7 6.7 6.4 5.9 5.2 4.8 4.8 4.0 4.2 4.4 5.0 5.0  
## 1997 6.4 6.5 6.3 5.9 4.9 4.8 4.5 4.0 4.1 4.3 4.8 5.0  
## 1998 6.2 5.7 5.6 4.6 4.0 4.2 4.1 3.6 3.7 4.1 4.3 4.0  
## 1999 4.9 5.0 4.6 4.3 3.9 4.0 3.6 3.3 3.1 3.3 3.7 3.7  
## 2000 4.4 4.4 4.1 3.5 3.1 3.0 2.8 2.5 2.6 2.8 3.1 3.0  
## 2001 3.9 4.2 4.0 4.1 3.5 3.5 3.4 3.1 3.4 3.7 4.0 4.0  
## 2002 5.0 4.9 5.0 4.7 4.0 4.2 4.0 3.6 3.7 3.9 4.5 4.6  
## 2003 5.6 5.8 5.6 5.5 4.8 4.9 4.8 4.3 4.5 4.6 4.8 4.7  
## 2004 5.6 5.6 5.5 4.8 4.2 4.3 4.2 3.8 4.0 4.2 4.6 4.6  
## 2005 5.5 5.8 5.5 5.2 4.7 4.6 4.5 4.1 4.4 4.4 4.8 4.6  
## 2006 5.3 5.6 4.9 4.6 4.2 4.4 4.4 3.9
```

```
Maine.annual.ts <- aggregate(Maine.month.ts)/12  
layout(1:2)  
plot(Maine.month.ts)  
plot(Maine.annual.ts)
```



```
Maine.Feb <- window(Maine.month.ts, start = c(1996,2), freq = TRUE)
Maine.Aug <- window(Maine.month.ts, start = c(1996,8), freq = TRUE)
Feb.ratio <- mean(Maine.Feb) / mean(Maine.month.ts)
Aug.ratio <- mean(Maine.Aug) / mean(Maine.month.ts)
```