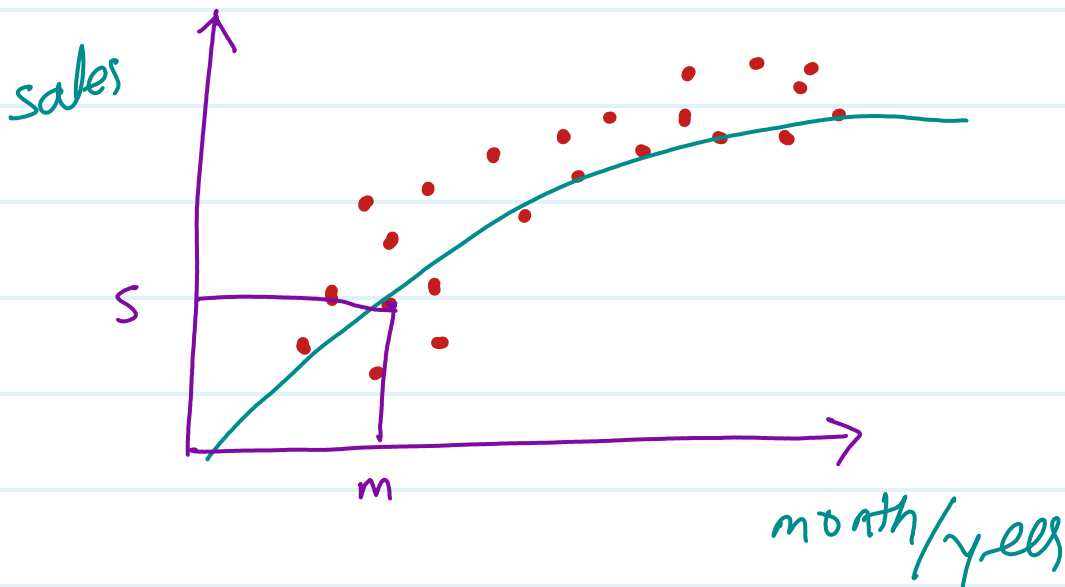


# Time Series

What Time Series and non-Time series problem

## ① Non-Time-Series

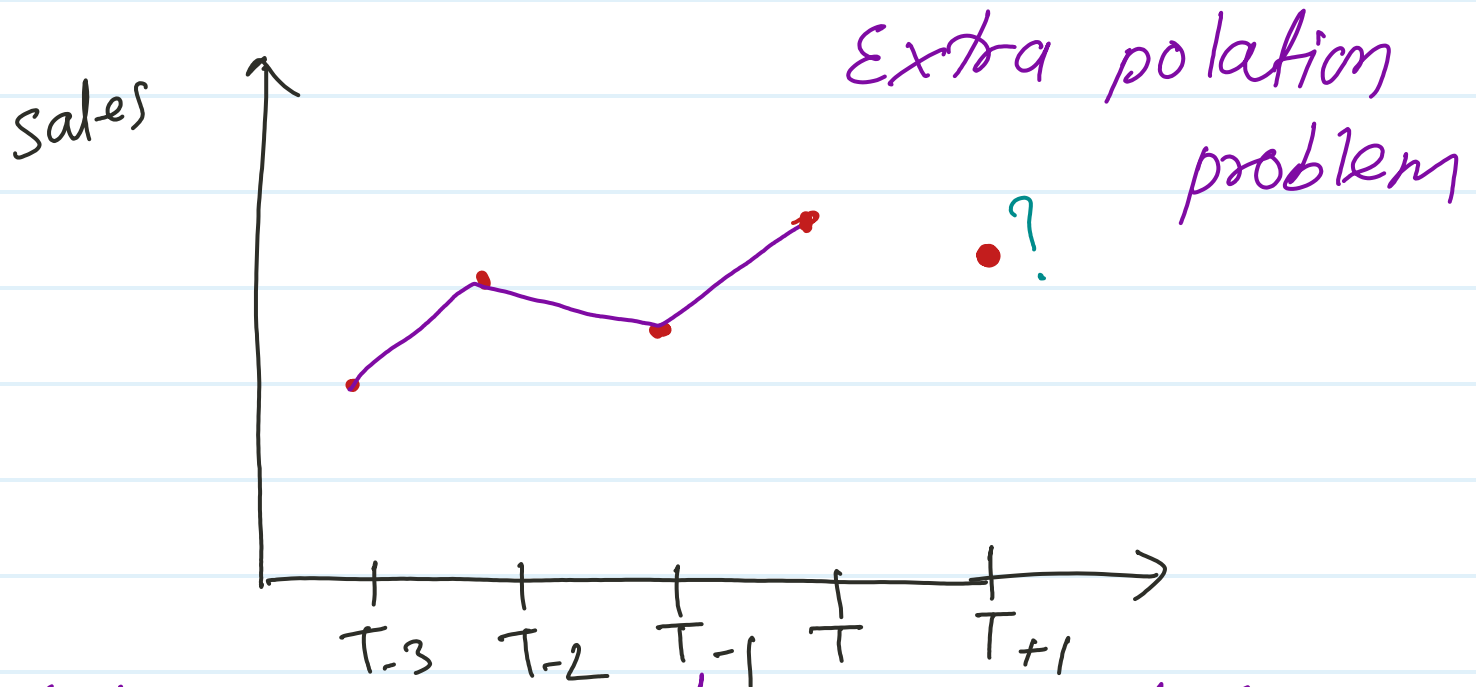


Interpolation problem

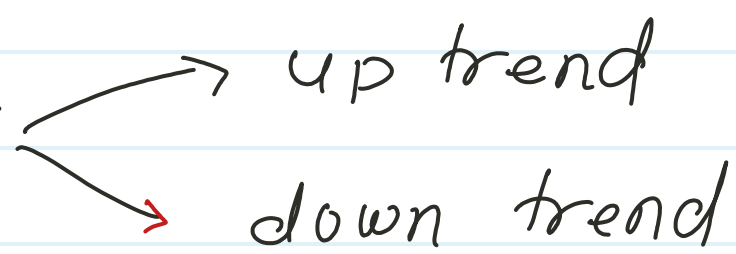
Here, we are predicting sales value on the basis on previous data like we did in regression problem. It is called Interpolation problem.

It is basically supervised ML problem.

## ② Time series -



When we are forecasting future price based on current or may be past lag it called extra polation problem.

- ① Level - calculate the avg of data.
- ② Trend - 
  - up trend
  - down trend
- ③ Seasonality - for example sales depends on season
- ④ Cyclic pattern - Repeat trend after a long period like after a year.
- ⑤ Noise - Where no pattern and trend identified in the data.

ARIMA (Auto Regressive Integrated moving Average)

① AR Auto Regressive P  
predict the current value using  
a weighted sum of past observation.

$$Y_t = C + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \dots + \phi_p Y_{t-p} + \epsilon_t$$

here

$Y_t$  = current value

$Y_{t-1}, Y_{t-2}$  = past value (lags)

$\phi_1, \phi_2$  = coefficients (weight)

$\epsilon_t$  = error term / Residual

exam predicting today's temp  
using past 3 day's

Day	Temp $^{\circ}\text{C}$
mon $t-2$	28.
Tue $t-1$	30.
Today $t$	?

we use  $p=2$  mon, Tue

$$\text{Temp}_t = c + \phi_1 \text{Temp}_{\text{Tue}} + \phi_2 \text{Temp}_{\text{mon}} + \epsilon$$

② Integrated (1) d making data stationary

Arima required the data have  
constant mean and variance

But real data often use  
trend and seasonality

We remove them by differencing.

$$Y'_t = Y_t - Y_{t-1}$$

if  $d = 1$ , we subtract previous  
value

$$Y'_t = Y_t - Y_{t-1}$$

if  $d = 2$ , we diff. again

$$Y''_t = Y'_t - Y'_{t-1}$$

③ moving Average (MA) 9

use past forecast error

predict current value using past forecast error

$$Y_t = C + \theta_1 e_{t-1} + \theta_2 e_{t-2} + \dots + \theta_q e_{t-q} + e_t$$

$e_{t-1}$  = Past error residual

$\theta_1, \theta_2$  = weights for past error

ARIMA parameters

- $p$  (AR) - how many past value to include 1, 2, 3, ...
- $d$  (I) - how many time to diff. data 1 or 2
- $q$  (MA) - how many past error to include 1, 2, 3, ...

$p, d, q$

ARIMA (1, 1, 1) means

- use 1 past value
- Diff. one to make stationary
- use 1 past error

$$y^t = C + \frac{\phi_1 y_{t-1}'}{p} + \underbrace{\theta_1 e_{t-1}}_q + e_t \uparrow$$