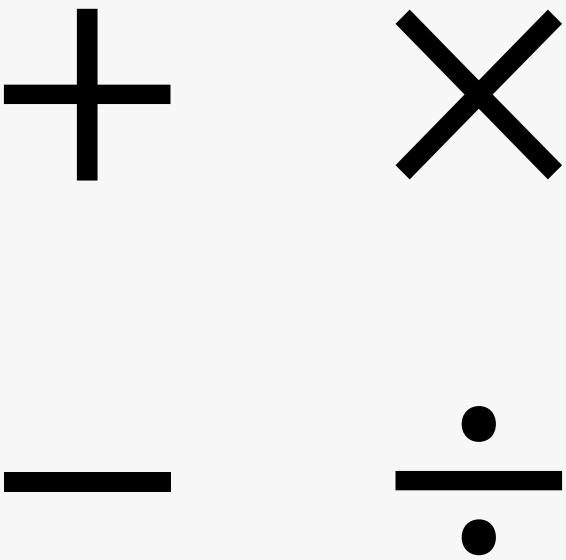


PHYSICS IS USEFUL FOR FUNDAMENTAL QUESTIONS IN ML

① MOTIVATION

- TO ENGENEER BETTER SOLUTION
- PASSION FOR UNDERSTANDING
- BLACK BOX → INTERPLETABILITY

② QUESTIONS

- OVERPARAMETERIZATION
- LOCAL MINIMUM

(IF I FIT SOME DATA WITH A LINEAR MODEL, BUT IF I USE A POLYNOMIAL OF DEGREE 5 I GET MANY OSCILLATIONS

③ WHY PHYSICS?

- MATHS PHYS PARAFRASERS
- BOUNDS ON REALIZABILITY

SCALING

POWER LAWS

$y = cx^{\alpha} \qquad \alpha \in \mathbb{R}$

SCALE INVARIANT $x' = \lambda x$

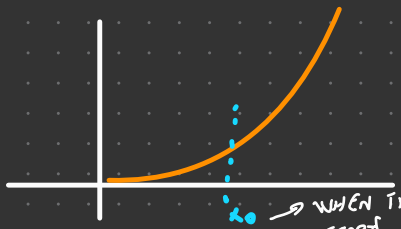
$$y = c\frac{x'^{\alpha}}{\lambda^{\alpha}} \rightarrow \underbrace{y\lambda^{\alpha}}_{y'} = cx'^{\alpha} \rightarrow$$

EXPONENTIAL ARE NOT SCALE INVARIANT

$y = ce^{\frac{x}{x_0}}$

$x' = \lambda x$

$y = ce^{x'/\lambda x_0}$



WHEN THE EXPONENTIAL STARTS TO INCREASE REALLY FAST

[BETTENCOUR PNAS 2007] ← REFERENCE

x^α $\alpha<1$ SUBLINEAR
$\alpha=1$ LINEAR
$\alpha>1$ SUPERLINEAR

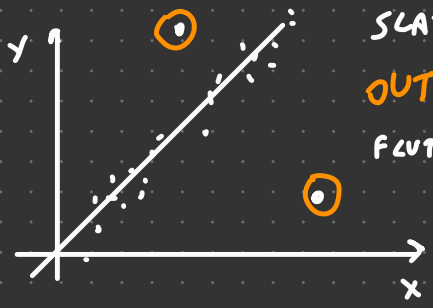
x = POPULATION

y = ELECTRIC CABLE LENGTH — $y \propto x^{0.87}$ — $0.87<1$ → SUBLINEAR SCALING

y = NUMBER OF GAS STATION — $y \propto x^{0.77}$ → SUBLINEAR SCALING

y = TOTAL ELECTRICAL CONSUMPTION — $y \propto x^1$ → LINEAR SCALING

y = AVERAGE WAGE — $y \propto x^{1.12}$ → SUPERLINEAR SCALING



SCATTER PLOT
OUTLIERS
FLUTTUATIONS

$y = cx^\alpha$ — $\log x$ — $\log y$

PROPERTY of PRODUCTS OF LOGARITH

$\log y = \log c + \alpha \log x$

$\log y$ = Y — $\log x$ = X

EXERCISE MODEL BUILDING

MODEL SCALE 1:100

$l \sim \frac{1}{100}$

HOW SLOW?

$t \sim \lambda t$ $\quad \lambda = ?$

$$l = \frac{1}{2} a t^2 + v_0^{\nearrow 0}$$

$$\downarrow$$

$$t = \sqrt{\frac{2l}{a}} \rightarrow t = \sqrt{\frac{200}{a}}$$