EECS 16A : Module 3 Last lecture.

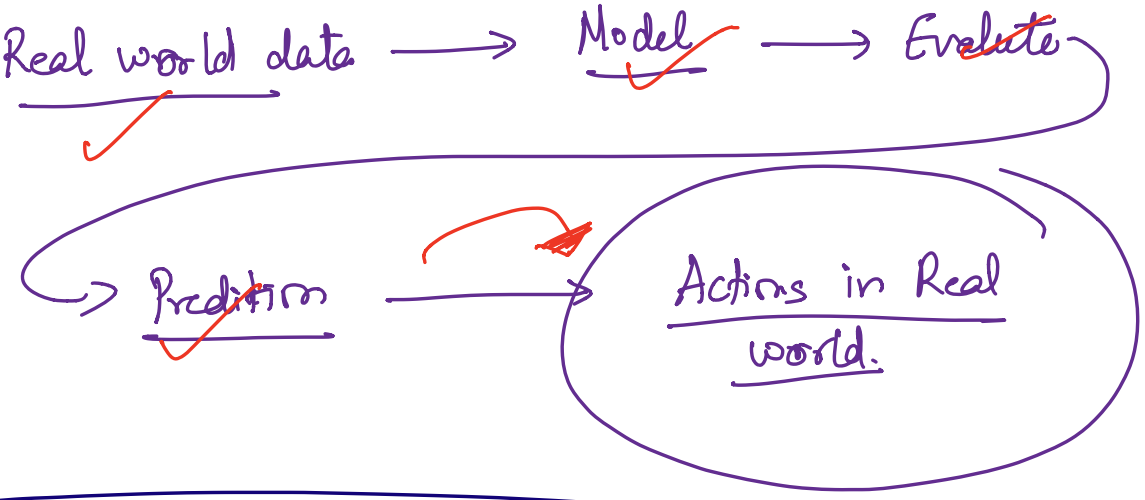
Today.

- GPS summary
- Course evaluations
- OMP.

Logistics

- Last lecture
- Please fill out survey.
- Thank your TAs.

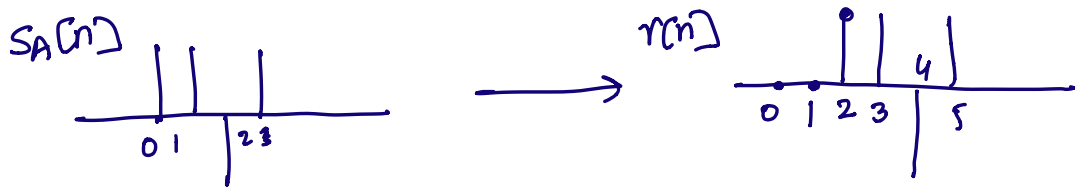
Machine Learning -



GPS

(1) - Identify which satellite is transmitting
  - Delay / Shift

$$\vec{r} = \underbrace{\vec{s}_A^{(k_1)}}_{\text{signature A with shift } k_1} + \vec{s}_B^{(k_2)} + \vec{s}_D^{(k_3)} + \vec{n}$$



$K_1 = 2$

$r[n] = s_A[n-2]$

$$\vec{r}[n] = \alpha_1 \vec{s}_A[n-k_1] + \alpha_2 \vec{s}_B[n-k_2] + \alpha_3 \vec{s}_D[n-k_3] + \vec{n}$$

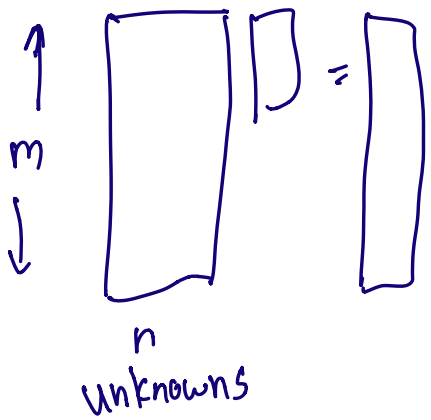
$$\begin{bmatrix} | \\ \vec{r}[n] \\ | \end{bmatrix} = \begin{bmatrix} | & | & | & | \\ \vec{s}_A[n-k_1] & \vec{s}_B[n-k_2] & \vec{s}_C[n-k_0] & \vec{s}_D[n-k_3] \\ | & | & | & | \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ 0 \\ \alpha_3 \end{bmatrix} + \vec{n}$$

(2) Delay / shift → Distance

(3) Trilateration : Distances ⟷ Position

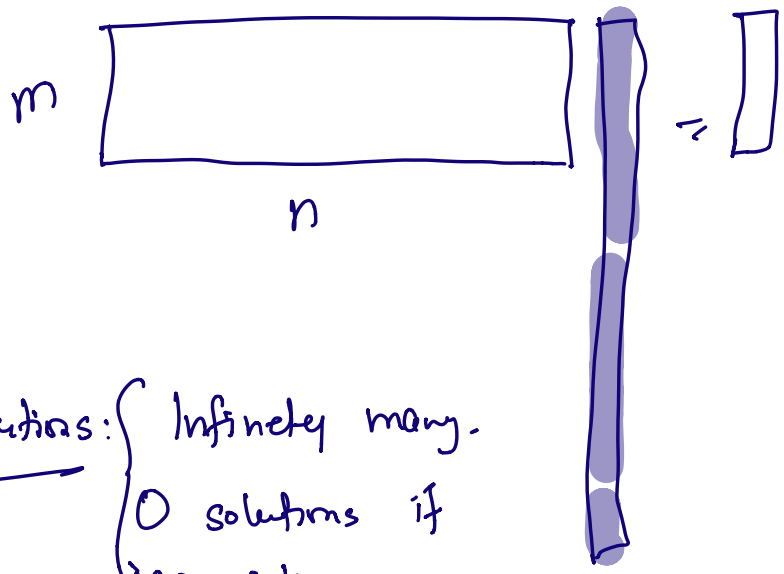
(4) To handle noise: Least Squares.
"estimate of your position"

- Easy to have measurements > unknowns



$m > n$

Different scenario:



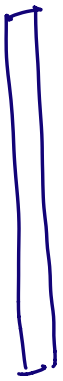
Solutions:
- Infinitely many.
- 0 solutions if inconsistencies.

never unique solution.

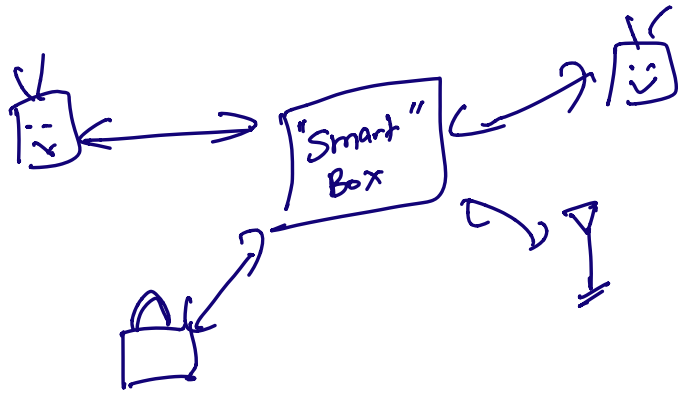
100 x 100 ⟶ 10^4 ⟶ 10^4 measurements

YES: Special cases we can solve:

SPARSITY

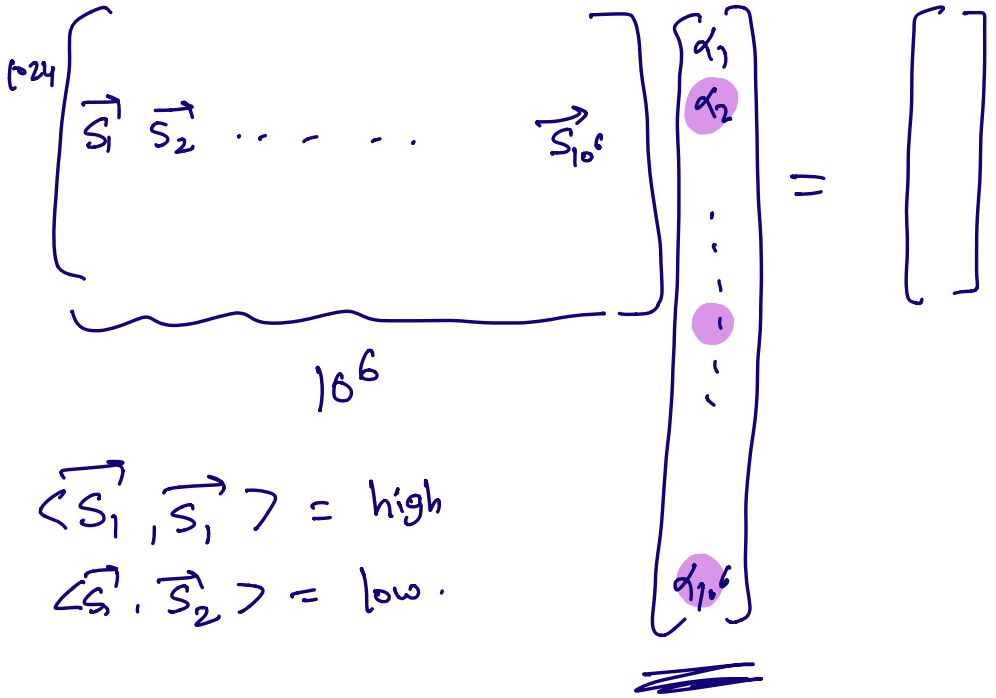
SPARSITY :  → most of the entries are 0

Internet of Things : millions of devices



$\vec{s_1}$ $\vec{s_2}$ .... $\vec{s_{10^6}}$ ...

$\vec{r} = \alpha_1 \vec{s_1} + \alpha_2 \vec{s_2} + \dots + \alpha_n \vec{s_n}$ Most of the devices



$\langle \vec{s_1}, \vec{s_1} \rangle$ = high

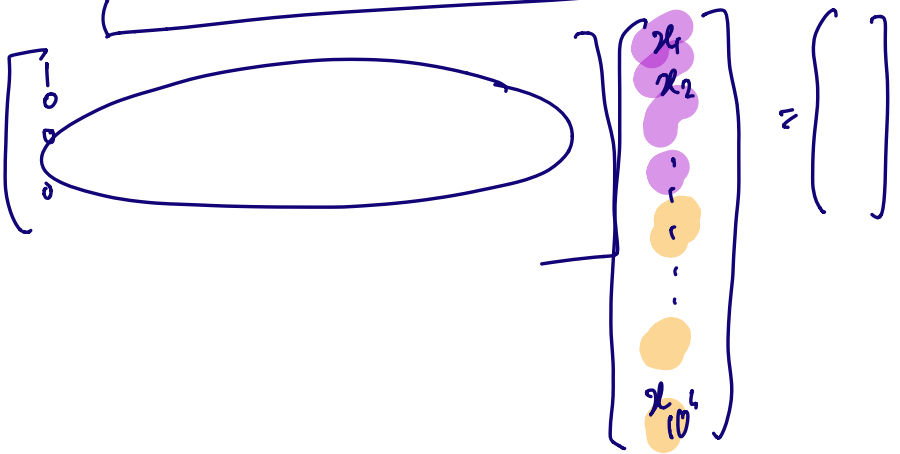
$\langle \vec{s_1}, \vec{s_2} \rangle$ = low.

Most entries are zero, some are non-zero!

SPARSE

Imaging $100 \times 100 = 10^4$ pixels

6000, 7000



Office hours

$\langle \vec{S_A}, \vec{S_A} \rangle = 1024$

$\langle \vec{S_B}, \vec{S_A} \rangle \approx 0$

$$\vec{r} = \vec{S_A} + \frac{1}{2}\vec{S_B}$$

$$\langle \vec{r}, \vec{S_A} \rangle = \langle \vec{S_A} + \frac{1}{2}\vec{S_B}, \vec{S_A} \rangle .$$

$$= \langle \vec{S_A}, \vec{S_A} \rangle + \frac{1}{2} \langle \vec{S_B}, \vec{S_A} \rangle .$$

$$= 1024$$