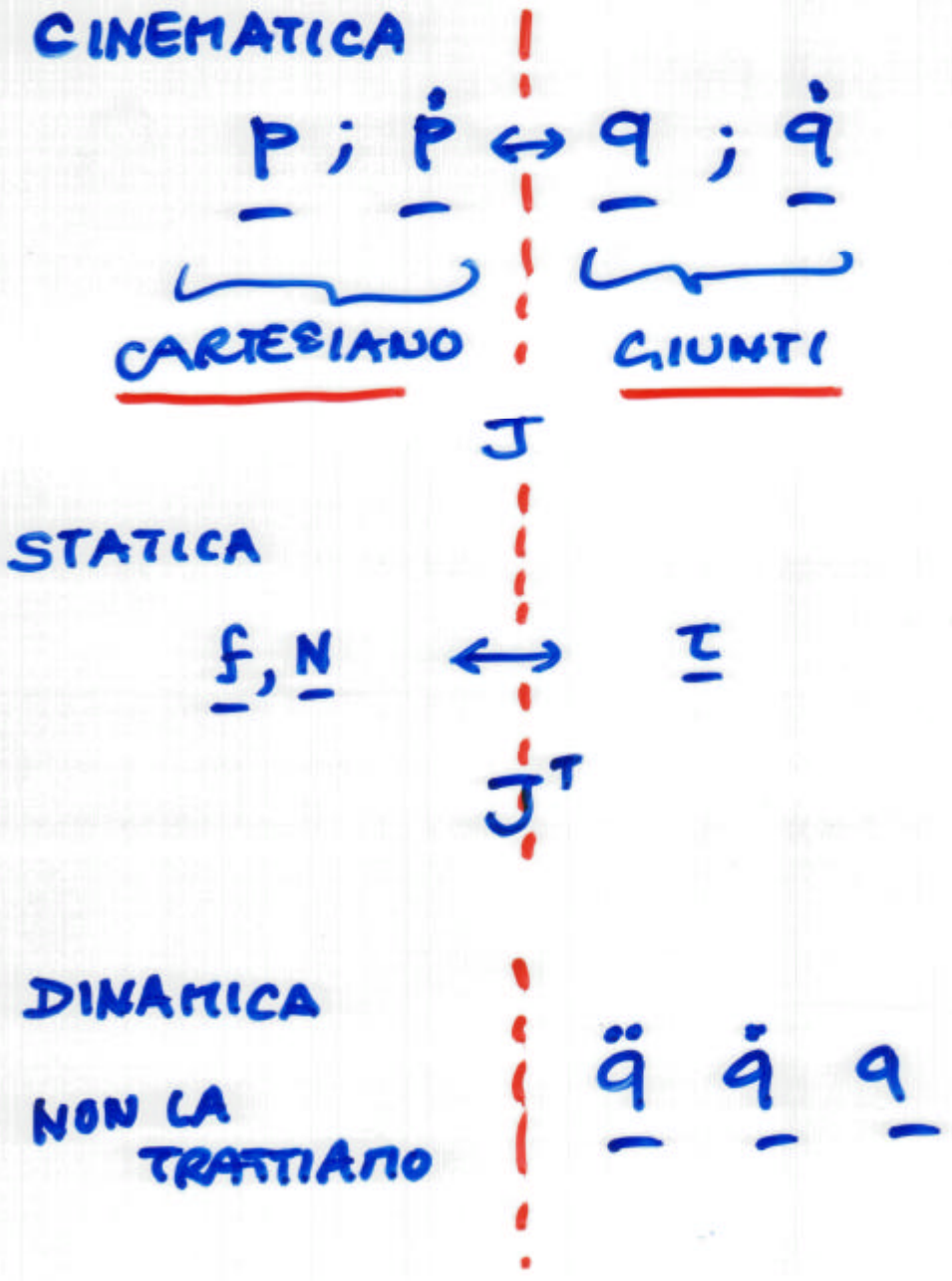

CINEMATICA
p ; ṗ ↔ q ; q̇
CARTESIANO
GIUNTI
J
STATICA
f, N ↔ τ
J^T
DINAMICA
NON LA TRATTIAMO
q̈ q̇ q

$$H(\underline{q})\ddot{\underline{q}}(t) + C(\dot{\underline{q}}, \underline{q})\dot{q}(t) + \underline{g}(\underline{q}) = \underline{\tau}(t)$$

forze generalizz. di comando

se il robot interagisce con ambiente

$$\ldots = \tau(t) \pm J^T \underline{F}$$

forze di scambio

IDENTIFICARE IL MODELLO

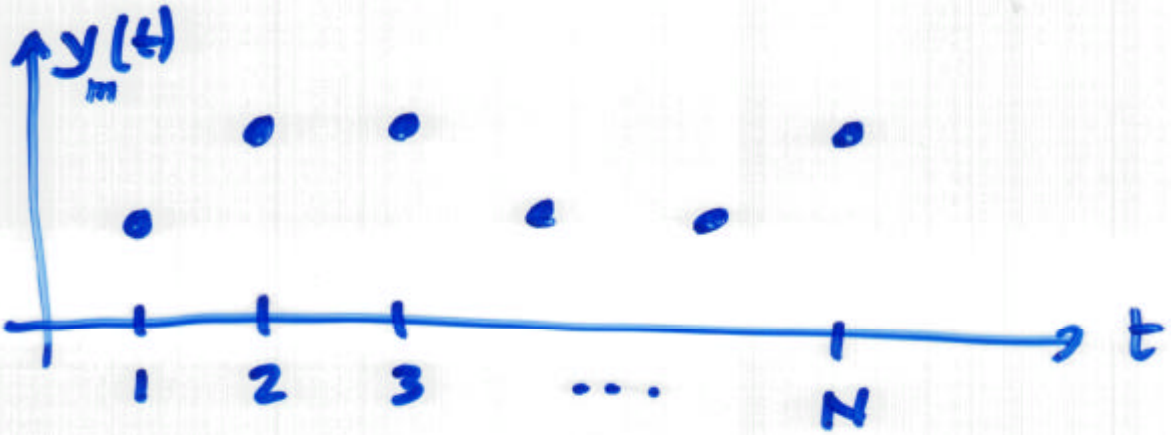
STIMARE I PARAMETRI

↓

- CREARE UNA FUNZIONE DELL'ERRORE TRA DATI REALI E DATI SIMULATI, FUNZIONE DEI PARAMETRI INCOGNITI
- MINIMIZZO LA FUNZ. RISPETTO AI PARAMETRI.

ESEMPIO

ABBIAMO 10 DATI SPERIMENTALI



MODELLO DI COSTANTE

$$y(t) = c$$

FUNZIONE ERRORE

$$\sum_{i=1}^{N} (y_m(t_i) - y(t_i))^2 \geq 0$$

$$\Downarrow$$

$$\sum_{i=1}^{N} (y_m(t_i) - c)^2$$

LSM
LEAST SQUARE
METHOD

$$c^* = \min_c \sum_{i=1}^{n} (y_m(t_i) - c))^2$$

$f(c)$

$$[c \quad a^1 \quad a^2 \quad \cdots \quad a^{N-1}] \begin{bmatrix} f^t_{N-1} \\ \vdots \\ f^t_1 \\ 1 \end{bmatrix}$$

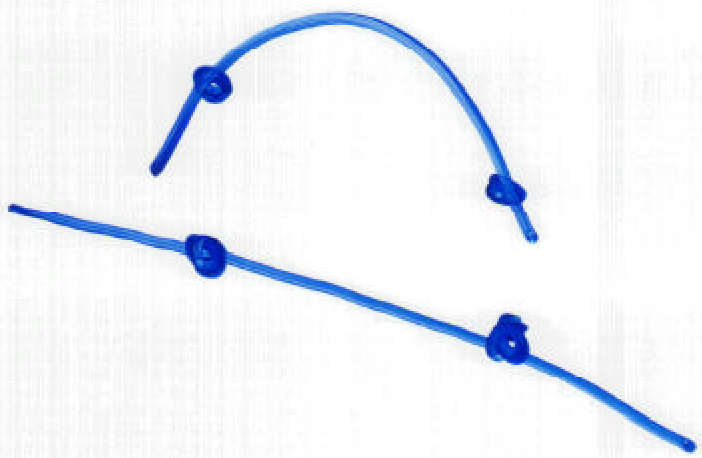
M_N $\quad \lambda_N(f) = c + a^1 f^t_1 + \cdots + a^{N-1} f^t_{N-1}$

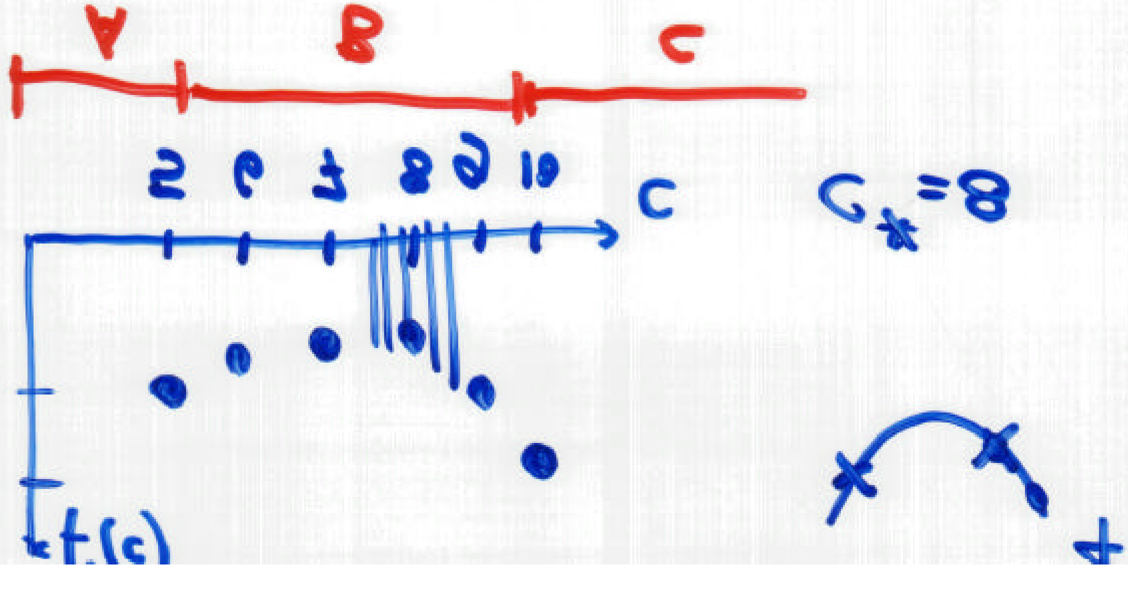
M_3 $\quad \lambda_{III}(f) = c + a^1 f^t_1 + a^2 f^t_2 \qquad c, a^1, a^2$

M_2 $\quad \lambda_{II}(f) = c + a f^t \qquad c, a$

M_1 $\quad \lambda_I(f) = c \qquad c$

MODELLO LINEARE NEI PARAMETRI





$$\begin{bmatrix} 1 & t_i & t_i^2 & \dots & t_i^{n-1} \end{bmatrix} \begin{bmatrix} c \\ a_1 \\ \vdots \\ a_{n-1} \end{bmatrix}$$

$\underline{\phi}_i^T$ $\quad$ $\underline{\lambda}$

$i = 1, \dots, N$

PARAMETRI INCOGNITI

$$\begin{bmatrix} \\ \\ \\ \end{bmatrix} \begin{bmatrix} \underline{\phi}_1^T \\ \vdots \\ \underline{\phi}_N^T \end{bmatrix} \begin{bmatrix} \\ \\ \\ \end{bmatrix} \begin{bmatrix} \\ \underline{\lambda} \\ \\ \end{bmatrix} = \underline{\Phi}\,\underline{\lambda}$$

MATRICE DEL REGRESSORE

$N \times n \cdot n \times 1$

$N \times 1$

$$\underline{\Phi}\,\underline{\lambda} \simeq \underline{y}_m(t_i) = \begin{bmatrix} y(t_1) \\ \vdots \\ y(t_N) \end{bmatrix}$$

MODELLO $\quad$ DATI $\quad$ $N \times 1$

MATRICE DI PROIEZIONE

$$\underline{\lambda}^* = \left(\underline{\Phi}^T \underline{\Phi}\right)^{-1} \underline{\Phi}^T \underline{y}_m$$

LEAST SQUARE

$$H\ddot{q} + C\dot{q} + g = \Phi\theta$$

REGRESSORE PARAMETRI

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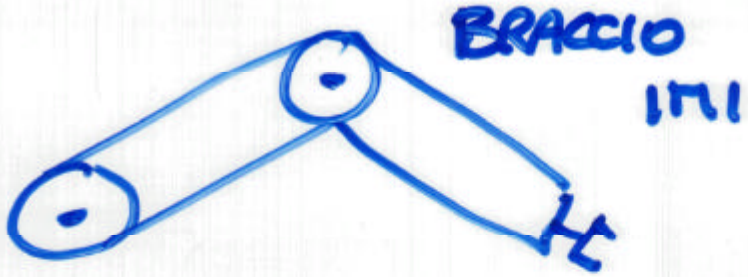
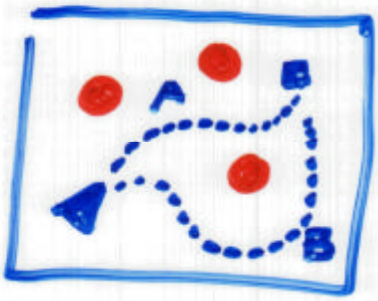
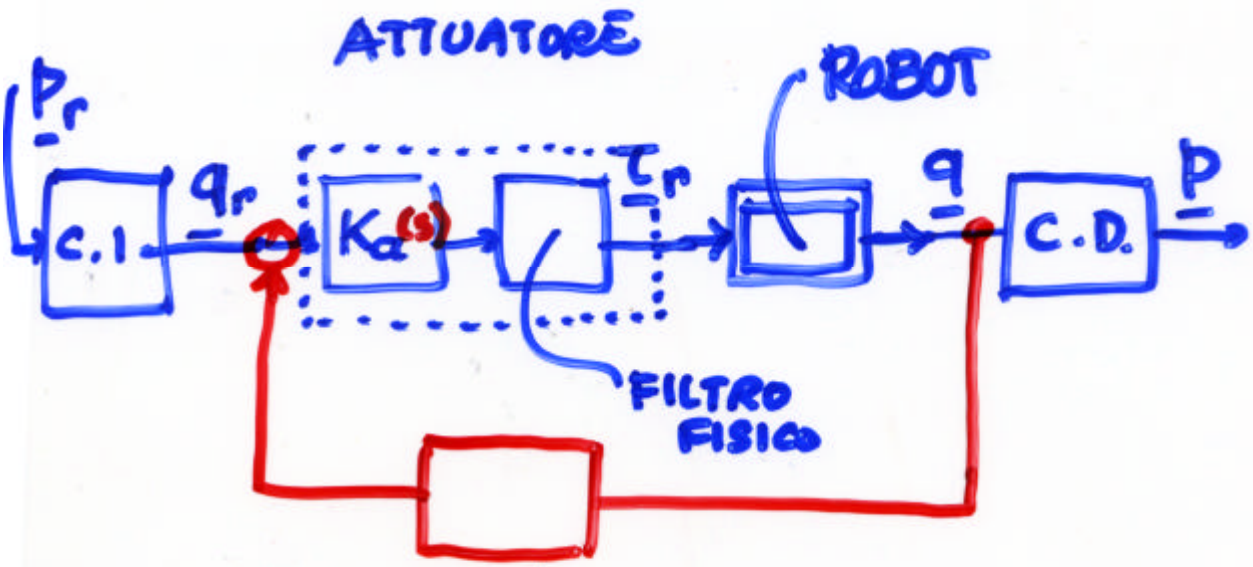


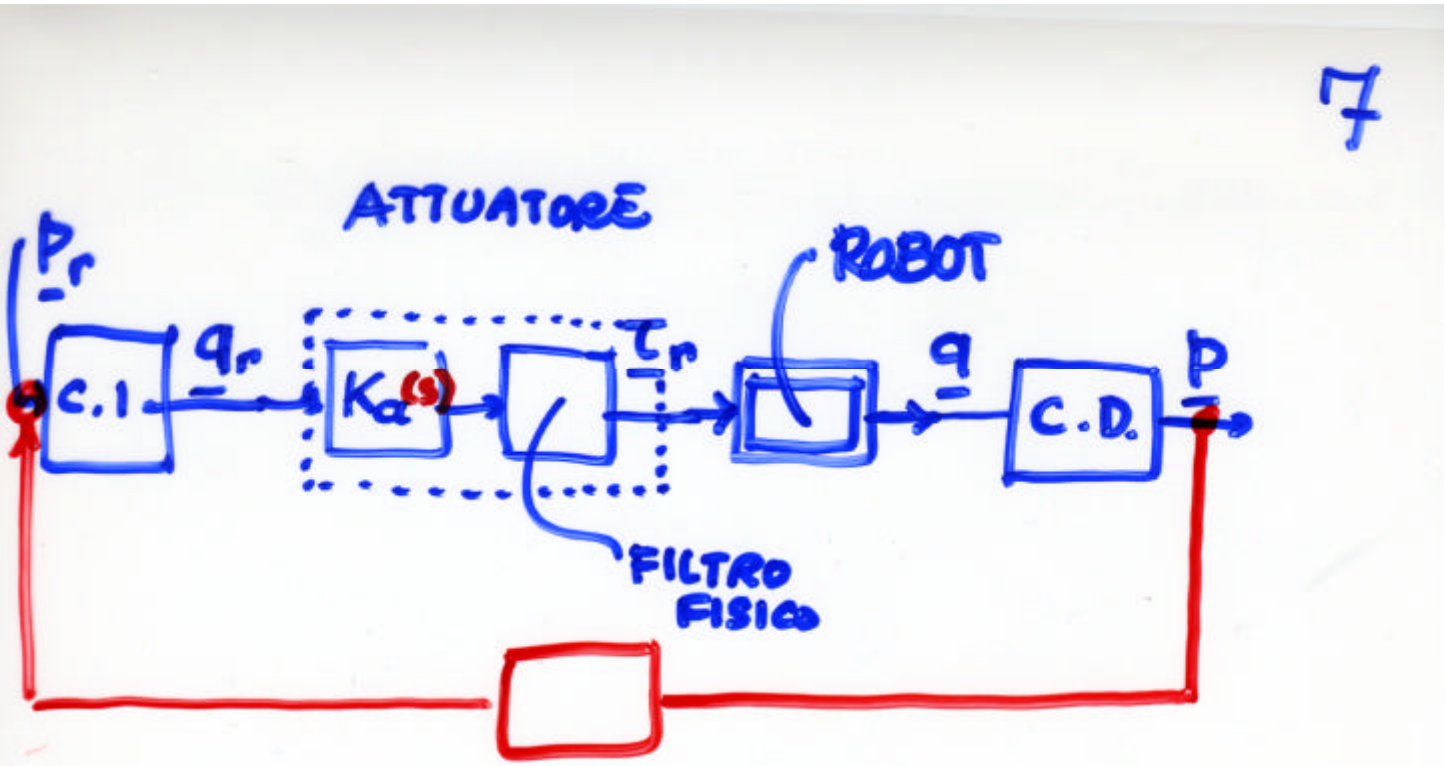
CONTROLLO

PIANIFICAZIONE TOP-DOWN

- OBBIETTIVO
- COMPITO / TASK
- OPERAZIONE
- MOSSA / MOVE
- TRAIETTORIA / CAMMINO
- RIFERIMENTO




ATTUATORE
ROBOT
$\underline{p}_r$
C.I
$\underline{q}_r$
$K_a(s)$
$\underline{\tau}_r$
$\underline{q}$
C.D.
$\underline{p}$
FILTRO FISICO


ATTUATORE
P_r
C.I
q_r
$K_a(s)$
τ_r
ROBOT
q
C.D.
P
FILTRO FISICO