State space method:

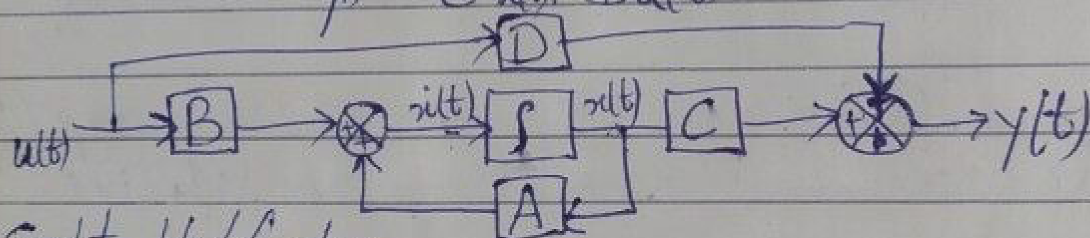
i) For MIMO systems representation

ii) Linear, non-linear, time variant and invariant systems

{A pole is always an eigenvalue but not the other way round. In t.f, a zero can cancel out a pole so that not all e.values occur in t.f as poles}

Linear t.i,

$$\dot{x}(t) = A\,x(t) + B\,u(t)$$
$$y(t) = C\,x(t) + D\,u(t)$$



Correlation b/w t.f and s.s

$$sX(s) - x(0) = AX(s) + BU(s) \rightarrow (i)$$
$$Y(s) = CX(s) + DU(s) \rightarrow (ii)$$

Take $x(0) = 0$, in (i).

$$sX(s) = AX(s) + BU(s)$$
$$sX(s) - AX(s) = BU(s)$$
$$(sI - A)X(s) = BU(s)$$
$$X(s) = (sI - A)^{-1} BU(s)$$

Put in (ii)

$$Y(s) = \left[C(sI - A)^{-1}B + D\right]U(s)$$

$$G(s) = Y(s)/U(s)$$
$$= \frac{\left[C(sI-A)^{-1}B + D\right]\cancel{U(s)}}{\cancel{U(s)}}$$

$$G(s) = C(sI - A)^{-1}B + D$$

Q $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + [0] u$$

Sol:- $G(s) = C(sI - A)^{-1} B + D$

$$= \begin{bmatrix} 1 & 0 \end{bmatrix} \left[s \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \right]^{-1} \begin{bmatrix} 0 \\ 1 \end{bmatrix} + [0]$$

$$= \begin{bmatrix} 1 & 0 \end{bmatrix} \left[\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \right]^{-1} \begin{bmatrix} 0 \\ 1 \end{bmatrix} + [0]$$

$$= \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 \end{bmatrix} \frac{1}{s(s+3)+2} \times \begin{bmatrix} s+3 & +1 \\ -2 & s \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$= \frac{1}{s^2+3s+2} \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ s \end{bmatrix}$$

$$= \frac{1}{s^2+3s+2} \times [1]$$

$$G(s) = \frac{1}{s^2+3s+2}$$

[num, den] = ss2tf(A, B, C, D)

[A, B, C, D] = tf2ss(num, den)

State var → The smallest set of variables that completely determine the state of system

. State vector → A vector having n number of set varbls that completely determine dynamic behv of system