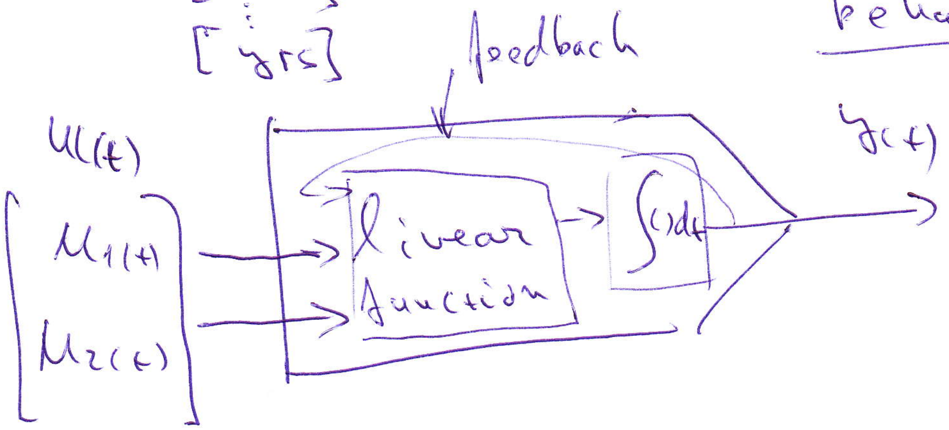
Continuous-time Dynamical Linear Models - types of output behavior

t ... time [sec]
[min]
⋮
[yrs]

behavior →
- stable
- unstable
- oscilating
- non-oscilating



1-st Order:

e.g. $\dot{y}(t) = a_0 \cdot y(t) + b_0 u(t)$

1-st order systems are 1-D system (for now do not consider external inputs)

1-st order linear models with zero or constant input:

$$\dot{y}(t) = a_0 \cdot y(t) + b_0$$

What output behavior we can reach with those models:

2-nd Order linear models with constant input

$$a_2 \ddot{y}(t) + a_1 \dot{y}(t) + a_0 \dot{y}(t) = b_0 \iff$$

analogical

$$\dot{X}_1(t) = a_1 X_1(t) + a_2 X_2$$
$$\dot{X}_2(t) = a_3 X_1(t) + a_4 X_2 + b$$

a_2, a_1 are different parameters $\iff$ $a_1 \dots a_4$ are different params

What output behavior we can reach with 2-nd order linear models with constant inputs?

What kind of output behavior for 3-rd, 4-th, ... N-th order linear dynamical systems?

What output behavior can we reach for 1-st order linear systems with non-constant inputs?

e.g. sinus input $\dot{y} = a_0 y(t) + b_0 \cos(\omega t + \varphi)$

?

What output behavior can we have for 2-nd order linear systems with sinus input?

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State, State Vector, State Space, State trajectory

a system:

$$\left[\dots a_2\ddot{y}(t) + a_1\dot{y}(t) + a_0 y(t) = b_0 u(t) + b_1\dot{u}(t) \dots\right]$$

is analogical to:

$$\left[\begin{array}{l} \dot{x}_1(t) = \alpha_{11}x_1(t) + \alpha_{12}x_2(t) + \dots \\ \dot{x}_2(t) = \alpha_{21}x_1(t) + \alpha_{22}x_2(t) + \dots \\ \vdots \qquad\qquad \ddots \qquad\qquad \ddots \end{array}\right]$$

State of a system should uniquely describe the system ~~ketka~~ future in the next computation moment

State vector $\rightarrow \left[\, y^{(n-1)}_{(t)} \; y^{(n-2)}_{(t)} \dots \ddot{y}_{(t)} \; \dot{y}_{(t)} \; y_{(t)} \right]$ of n-th order system

$\Downarrow$ OR ANALOGICALLY

State vector $\rightarrow \begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_n(t) \end{bmatrix}$