Signals in Control Systems

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Recap: so far we have introduced

Block diagrams: boxes and arrows

Different types of controls: open loop (feedforward), closed loop (feedback), mixed

Advantages and disadvantages of these control architectures

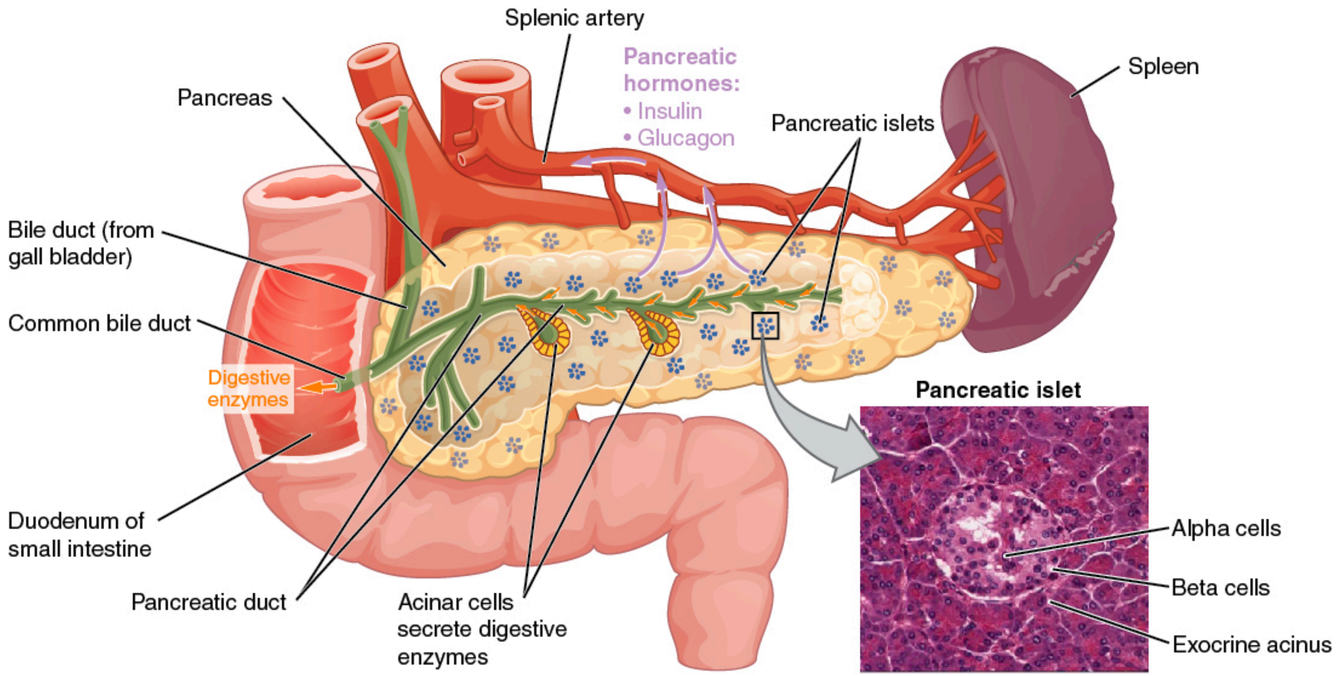
Application examples

Exercise 3: identify components of block diagrams

Objective: keep glucose concentration in blood at desired constant level

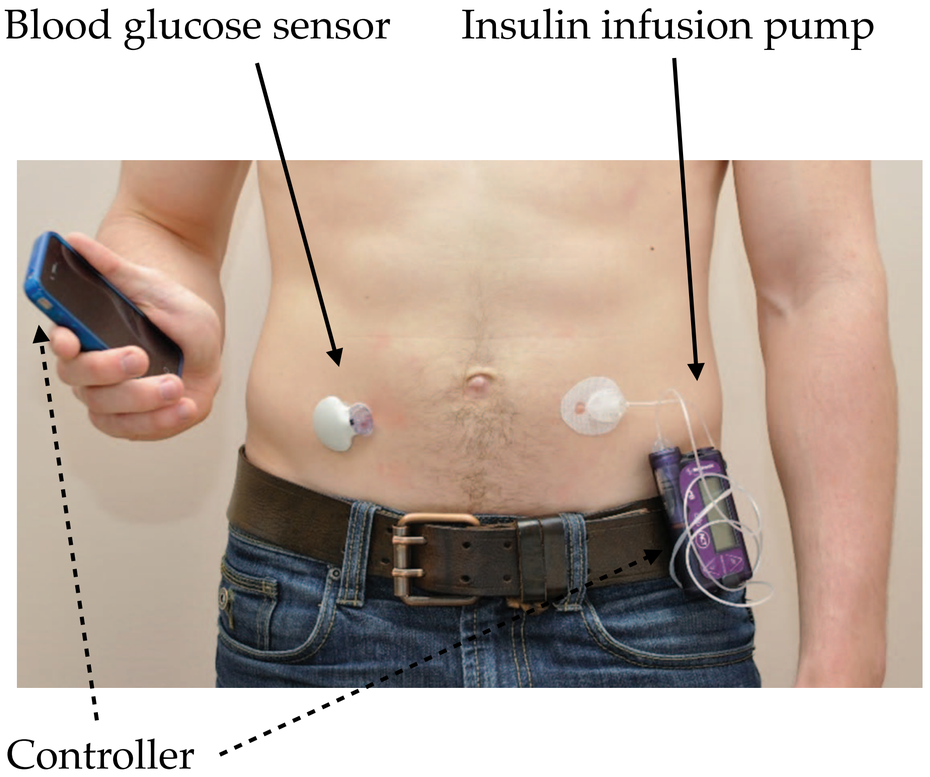
Beta cells ⇝ Insulin ⇝ Glucose ↓

Alpha cells ⇝ Glucagon ⇝ Glucose ↑



Natural pancreas

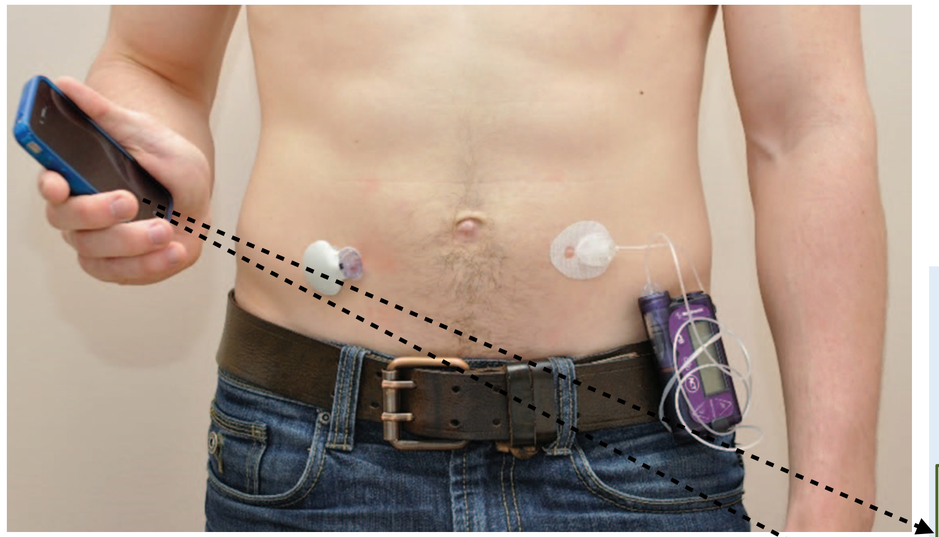
Question: what kind of "channels" do we have here?



Artificial pancreas

Image credit: Institut de Researches Cliniques de Montreal

Exercise 3: identify components of block diagrams



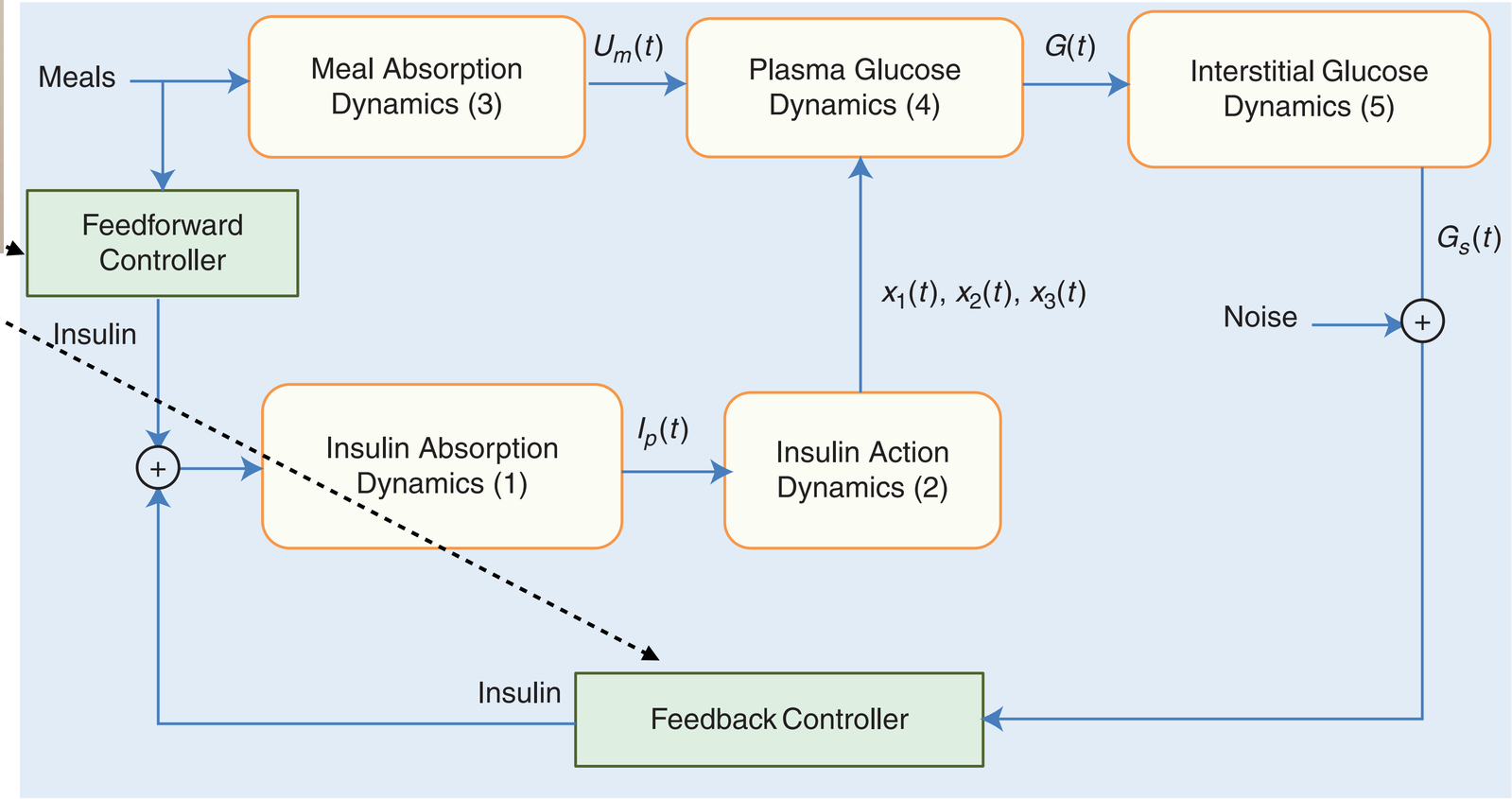


Image credit: A. Haidar, The artificial pancreas: how closed-loop control is revolutionizing Diabetes, *IEEE Control Systems Magazine*, Oct. 2016

Exercise 3: identify components of block diagrams

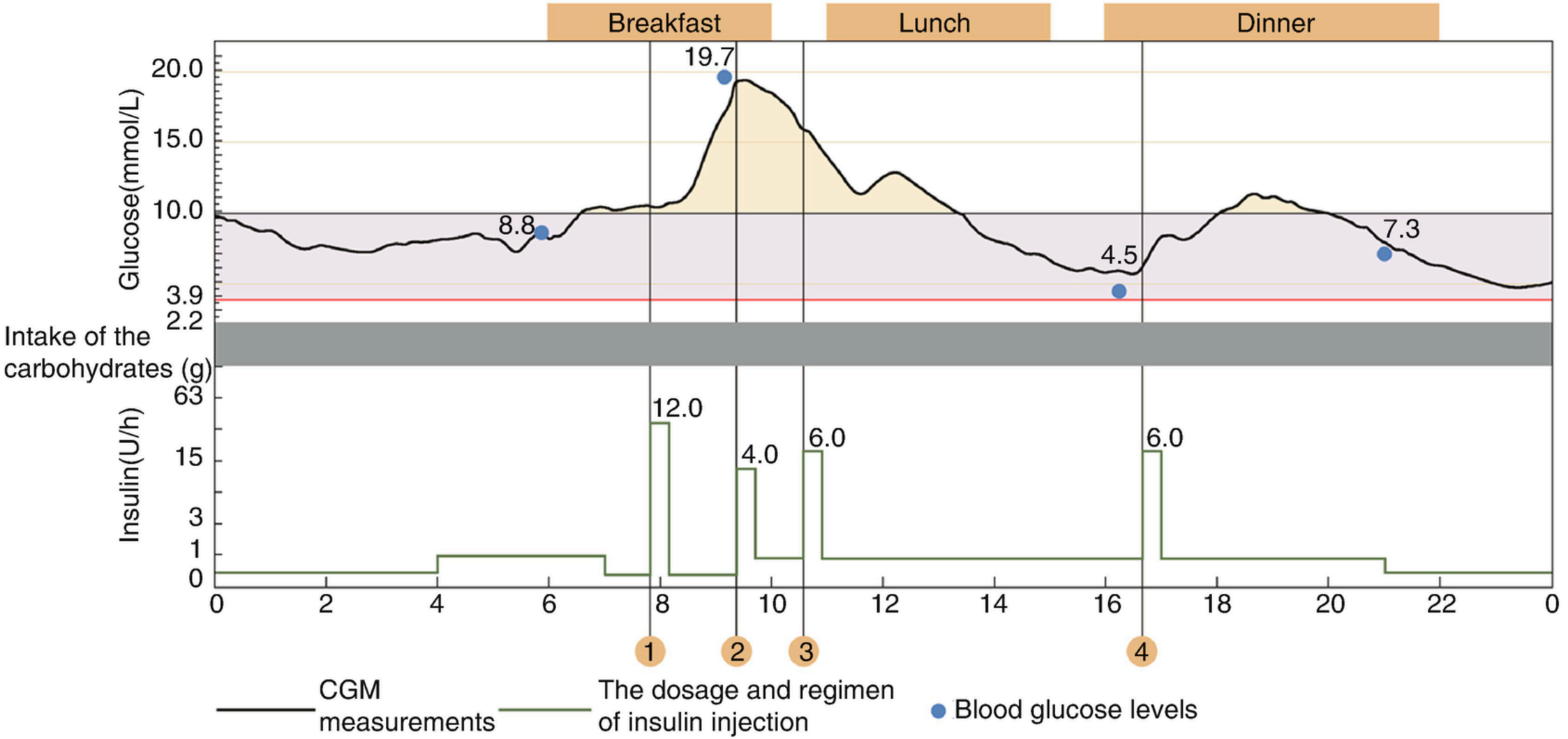


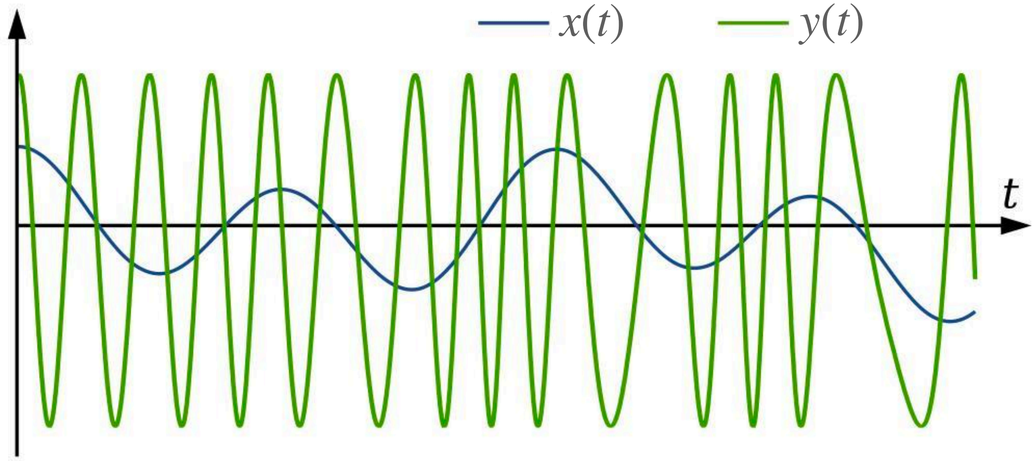
Image credit: M. Li, and Y. Bao, Methods for Interpreting Continuous Glucose Monitoring Graphs, *Continuous Glucose Monitoring*, pp. 35-46, 2018

The Concept of Signals

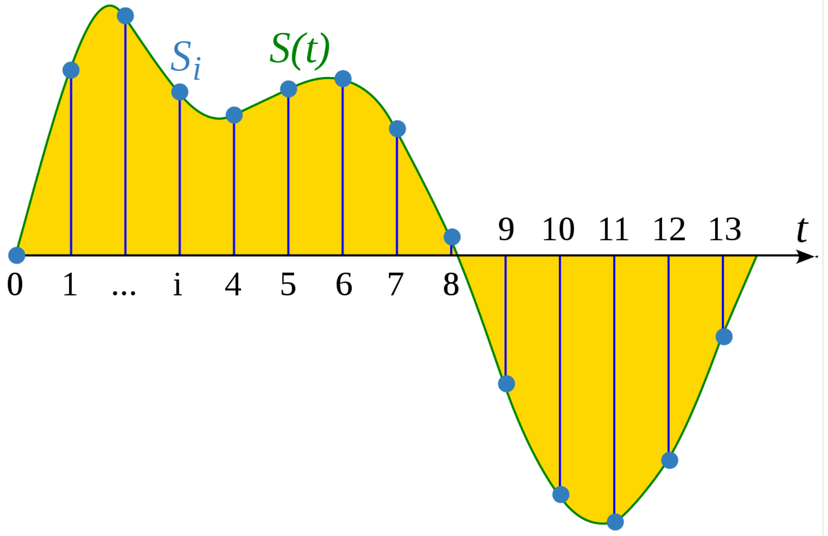
Signals ≡ functions of time

t	$S(t)$
t_0	$S(t_0)$
t_1	$S(t_1)$
t_2	$S(t_2)$
t_3	$S(t_3)$
⋮	⋮

Continuous time



Discrete (sampled) time

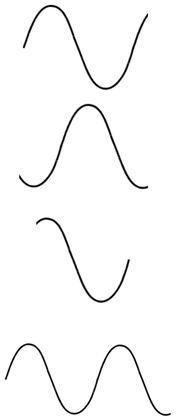


Other names for “signal”: “trajectory”, “time series” (usually for discrete time)

We can have a collection of different signals

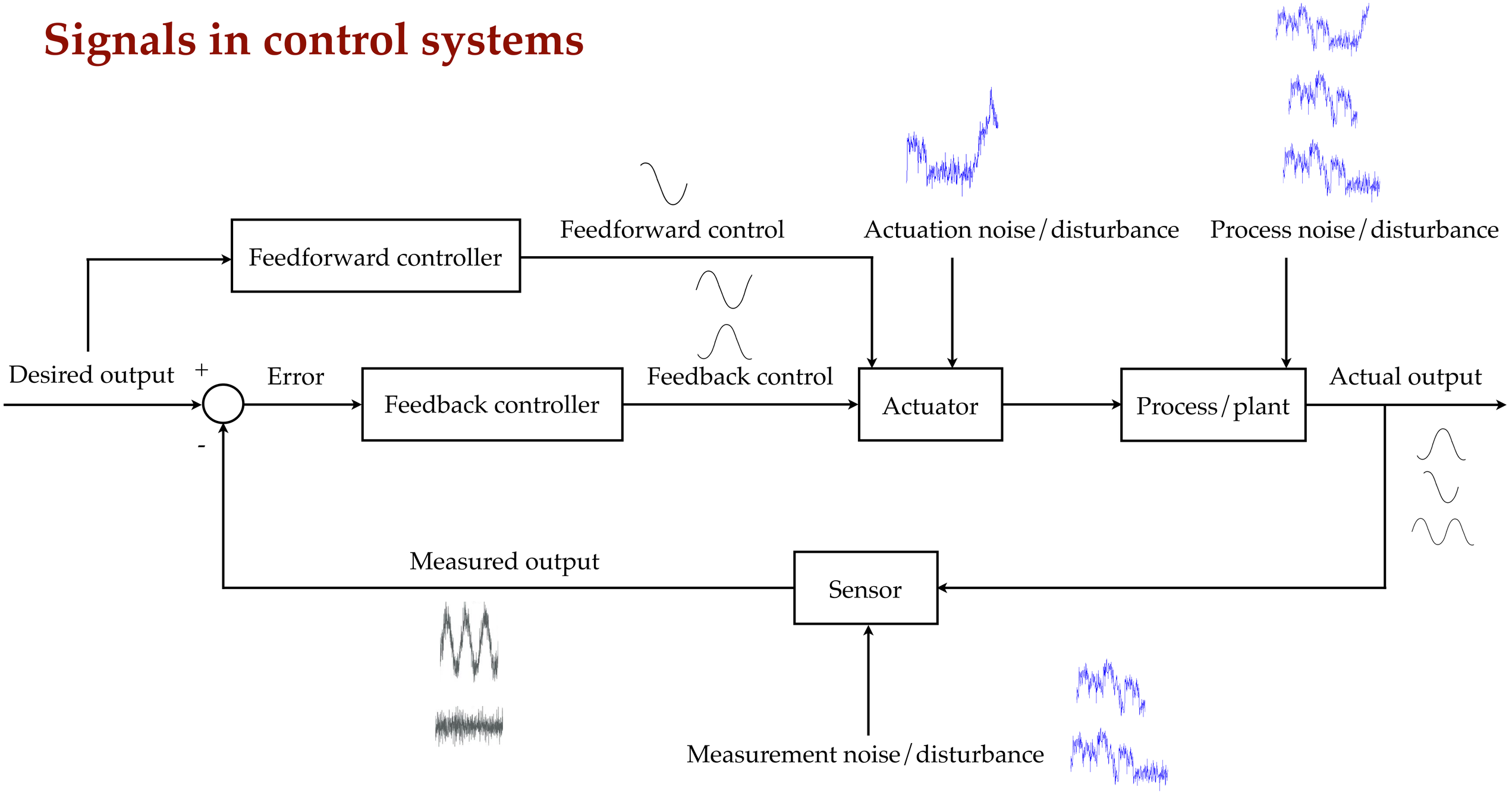
Continuous time

$$\begin{pmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \\ \vdots \\ x_n(t) \end{pmatrix}$$



called a **“vector”/“array”** of functions

Discrete (sampled) time

t	$S_1(t)$	$S_2(t)$	$\cdots$	$S_n(t)$
t_0	$S_1(t_0)$	$S_2(t_0)$	$\cdots$	$S_n(t_0)$
t_1	$S_1(t_1)$	$S_2(t_1)$	$\cdots$	$S_n(t_1)$
t_2	$S_1(t_2)$	$S_2(t_2)$	$\cdots$	$S_n(t_2)$
t_3	$S_1(t_3)$	$S_2(t_3)$		$S_n(t_3)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

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