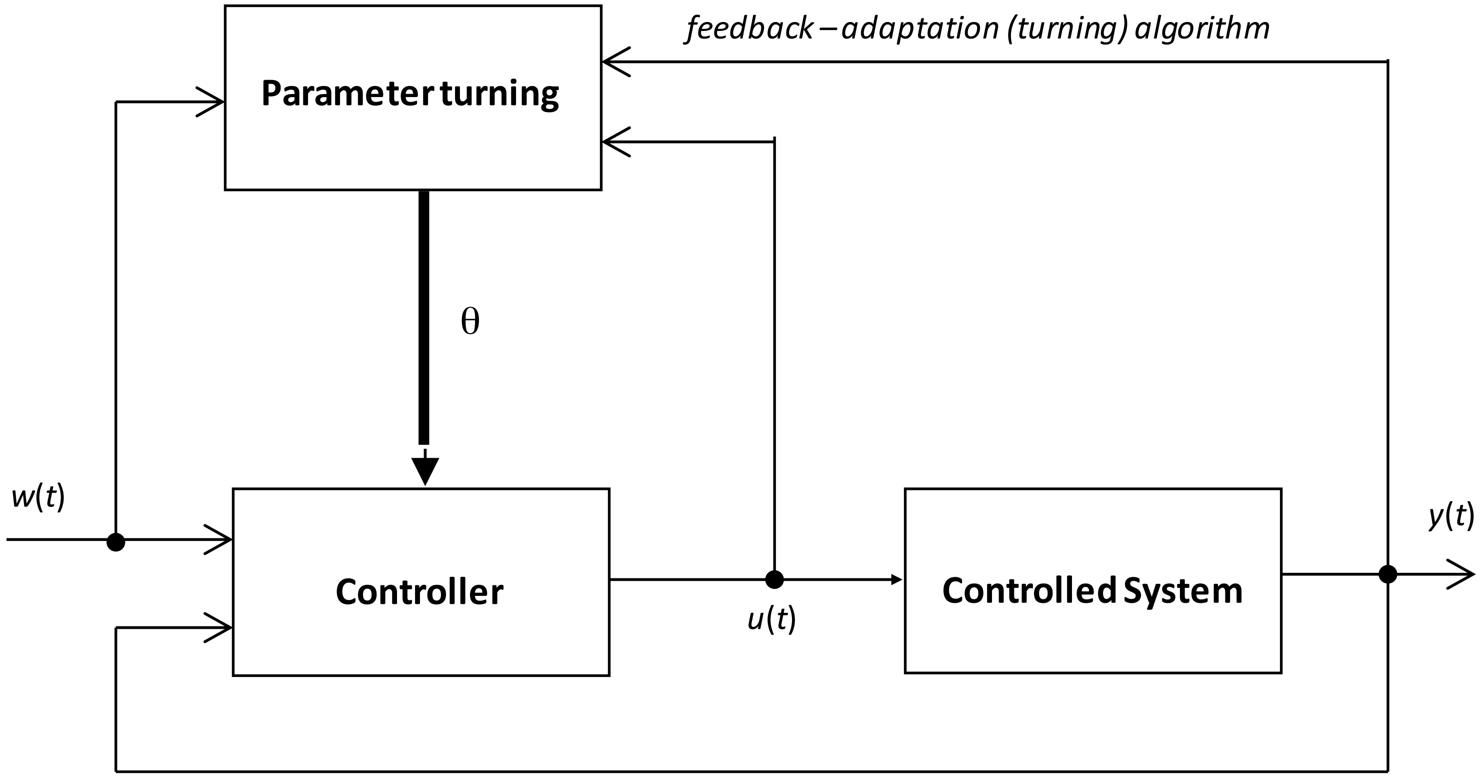
Part 1

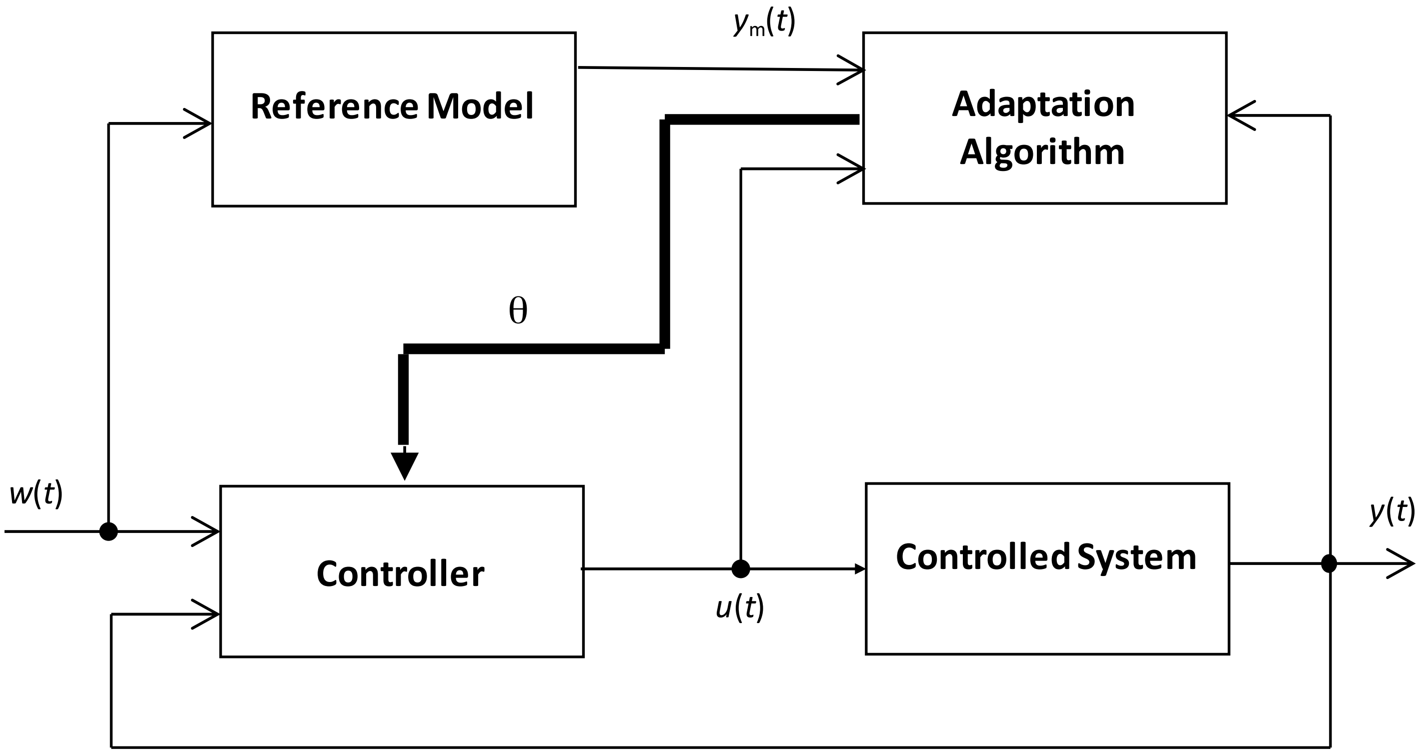
Reference Model based Adaptive Control

teoreetiline materjal: prof. Ennu Rüstern'i loengumaterjal "Ülevaade adaptiivsüsteemidest"

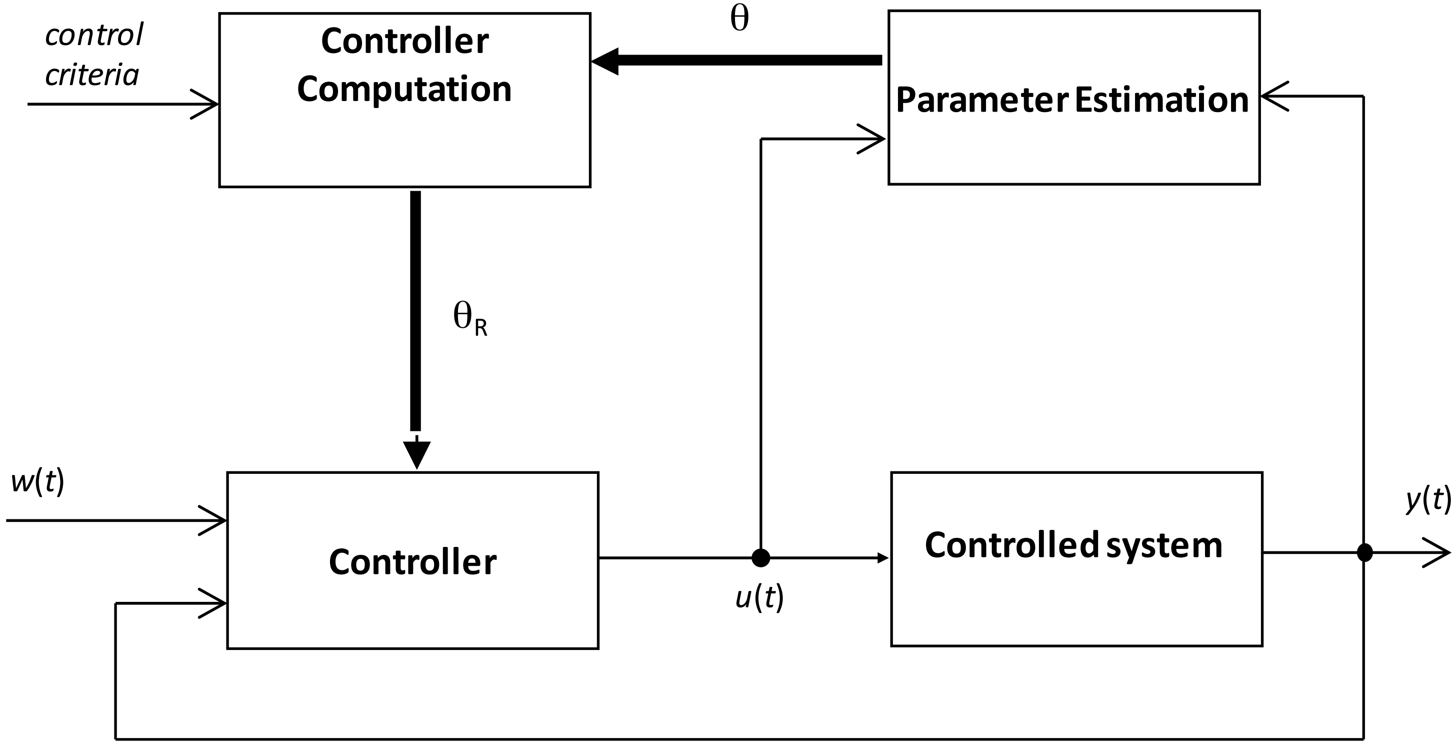
Structure of an Adaptive System



Reference Model based Adaptive System



Identification based Adaptive System



Reference Model based Control of a Nonlinear System

Controlled nonlinear system:

$$\dot{x}(t) = ax(t) + a_0 f(x) + bu(t)$$

Here **a** , $\mathbf{a_o}$ and **b** are unknown constants. State **x(t)** and function **f(x)** are measurable. Nonlinear function **f(x)** is a smooth function of state and **f(0)=0**.

Reference model:

$$\dot{\mathbf{x}}_\mathbf{m}(\mathbf{t}) = \mathbf{a_m x_m(t) + b_m w(t)}, \quad \mathbf{a_m < 0}$$

Reference Model based Control of a Nonlinear System

Turnable controller:

$$\mathbf{u(t) = -k_1(t)x(t) - k_2(t)f(x) + k_0(t)w(t)}$$

Turning algorithm

$$\mathbf{\dot{k}_1(t) = sign(b)e(t)x(t)}$$

$$\mathbf{\dot{k}_2(t) = sign(b)e(t)f(x)}$$

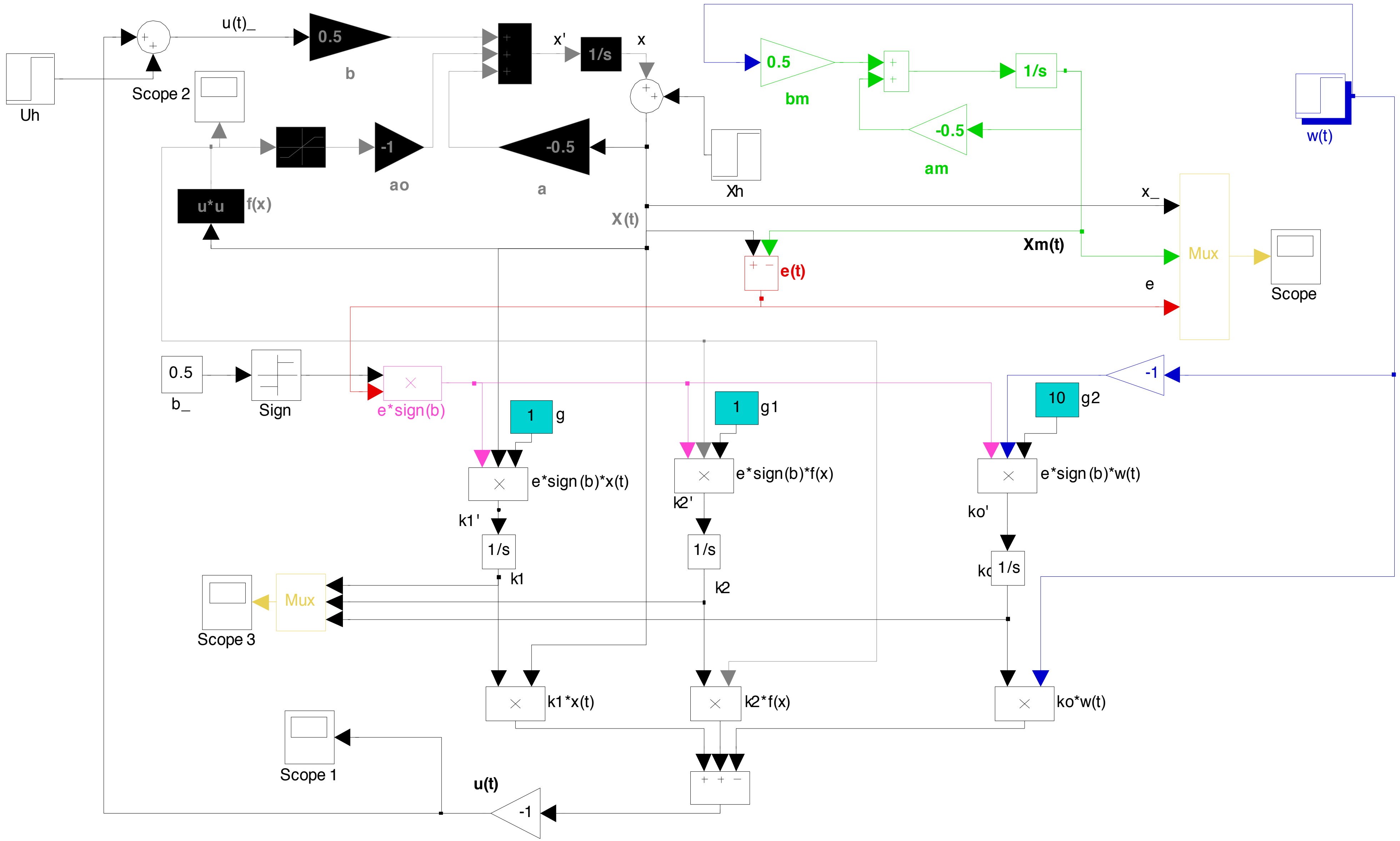
$$\mathbf{\dot{k}_0(t) = -sign(b)e(t)w(t)}$$

Let the error be $e(t) = x(t) - x_m(t) \to 0$

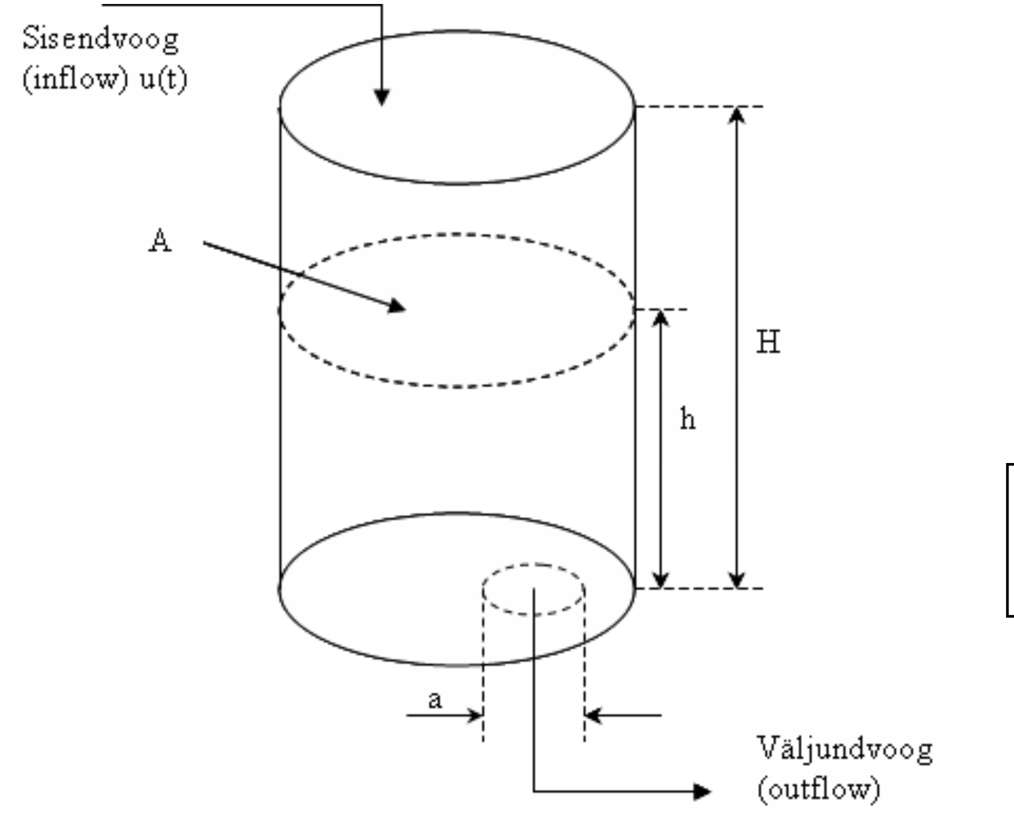
Equilibrium state $\mathbf{e(t)=0}$, $\mathbf{k_1(t)=k_1}$, $\mathbf{k_2(t)=k_2}$ and $\mathbf{k_o(t)=k_o}$ is stable, which means that the designed adaptive system precisely follows the reference model

Realisatsioon Simulink'is

(adaptiu1.mdl)



Nonlinear system – tank (liquid level control)



$$\frac{dV}{dt} = u(t) - outflow(t)$$

$$\rho g h = \frac{\rho v^2}{2}$$

$$outflow(t) = Sv = S\sqrt{2gh} \qquad \left(S = \frac{\pi a^2}{4}\right)$$

$$\boxed{\frac{dy}{dt} = \frac{1}{100AH}\left(u(t) - 100S\sqrt{2gHy(t)}\right)}$$

$$[u(t)] = \left[\frac{dal}{s}\right]$$

$$\left.\begin{aligned} H &= 0.5m \\ A &= 0.2m^2 (d \approx 0.16m) \\ a &\approx 0.04m \end{aligned}\right\} \Rightarrow \frac{dy}{dt} = u(t) - 0.44\sqrt{y(t)}$$