2.3 Adaptive Kontrolle (Optimalsteuerung)

$\dot{\underline{x}} = f(\underline{x}, \underline{u}, t)$ $\quad$ $\underline{x} \in \mathbb{C}^n$ Zustandsvektor

$\underline{u} \in \mathbb{C}^m$ Kontrollpar. (input)

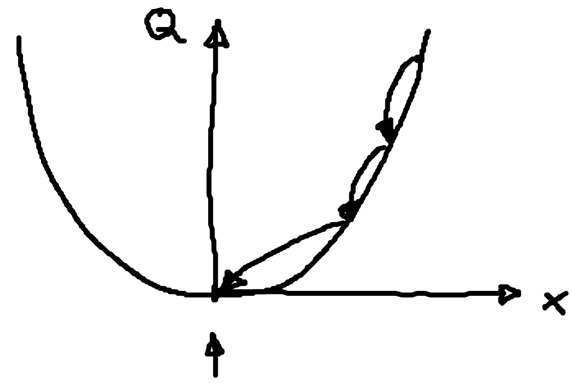
Kostenfunktion $Q(\underline{x}(t), t)$ minimalisieren!

(cost fct., goal fct.)

$Q \geq 0$

$\lim\limits_{t \to} Q(\underline{x}(t), t) = 0$

$\Rightarrow$ finde $\underline{u}(t)$



speed gradient method

A. Fradkov, Miroshnik, Nikiforov: Nonlinear and Adaptive Control of Complex Systems (Kluwer, Dordrecht 1999)

A. Fradkov: Cybernetical Physics: From Control of Chaos to Quantum Control (Springer 2007)

speed of Q: $\dot{Q} = \frac{\partial Q}{\partial t} + \underline{\nabla}_x Q(\underline{x}, t)\, \underbrace{\dot{\underline{x}}}_{= f(\underline{x}, \underline{u}, t)}$

hängt nicht von u ab

$$\boxed{\dot{u} = -\Gamma\, \underbrace{\underline{\nabla}_u \dot{Q}}}$$

Richtung im u-Raum, in der $\dot{Q}$ am stärksten abnimmt

$\Rightarrow \dot{Q} < 0 \quad \Rightarrow Q$ nimmt ab $\quad \Rightarrow \lim\limits_{t \to \infty} Q \to 0$

Anwendung: selbstadaptive Kontrolle der Rückkopplungsstärke K bei zeitverzög. Rückkopplung ($K \hat{=} u$)

• unbekannte oder driftende Systemparameter

Lehnert, Hövel, Flunkert, Guzenko, Fradkov, Schöll:
Chaos 21, 043111 (Okt. 2011)

Stabilisierung eines Fixpunktes:

$$\dot{x} = \lambda x + \omega y \quad - K\,[x(t) - x(t-\tau)] \qquad \lambda > 0$$
$$\dot{y} = -\omega x + \lambda y \quad - K\,[y(t) - y(t-\tau)] \qquad \text{Bif. par.}$$

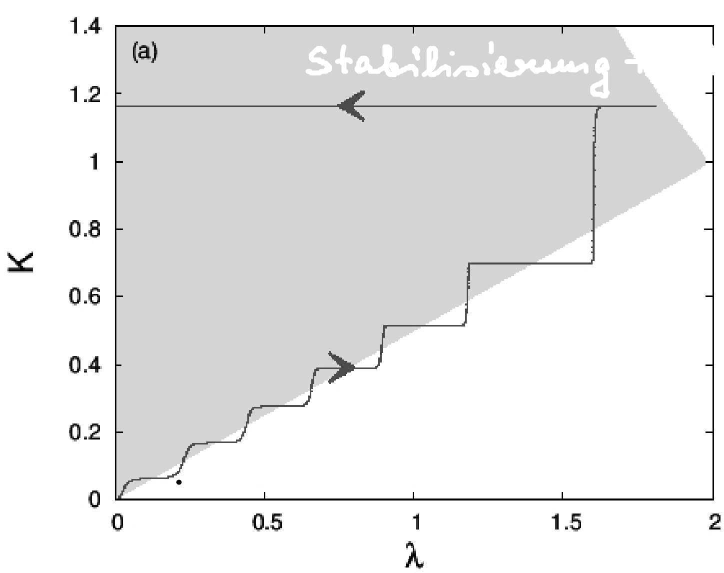
Fixpkt. $x^* = y^* = 0$, Eigenwerte $(K=0)$ $\lambda \pm i\omega$
$\Rightarrow$ inst. Fokus $(\lambda > 0)$

Kostenfkt. $Q = \frac{1}{2}\left[\left(x(t) - x(t-\tau)\right)^2 + \left(y(t) - y(t-\tau)\right)^2\right]$

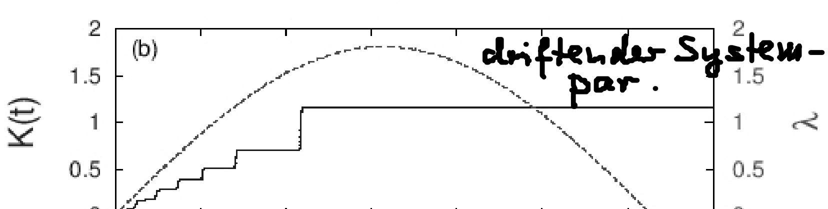
$$\dot{K} = -\Gamma \frac{\partial}{\partial K}\dot{Q} = -\Gamma\Big\{[x(t) - x(t-\tau)]\frac{\partial}{\partial K}[\dot{x}(t) - \dot{x}(t-\tau)] + [y(t) \ldots\ ]\Big\}$$

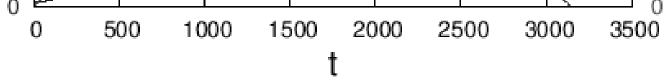
$$= \Gamma\Big\{[x(t) - x(t-\tau)]\left[\left(x(t) - x(t-\tau)\right) - \left(x(t-\tau) - x(t-2\tau)\right)\right] + [y(t) - \ \ldots\ ]\Big\}$$

$$= \Gamma\Big\{[x(t) - x(t-\tau)][x(t) - 2x(t-\tau) + x(t-2\tau)] + [y(t)\ \ldots\ ]\Big\}$$

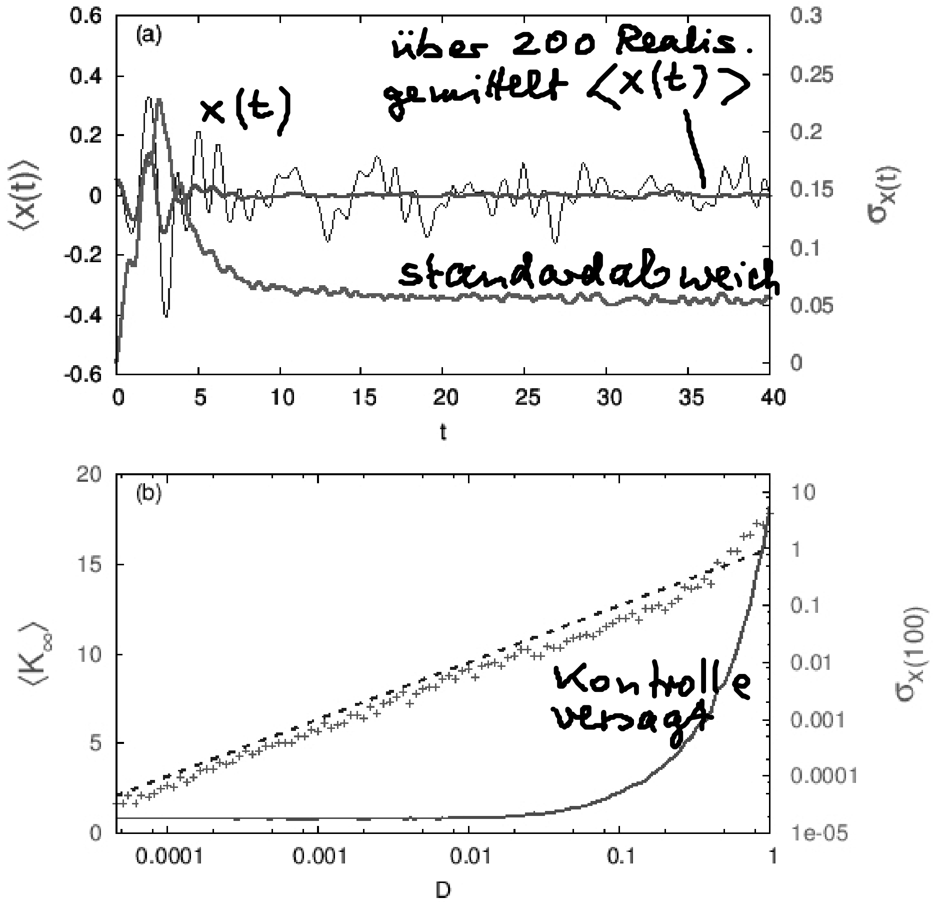


adaptive zeitverzögerte Rückkopplungskontrolle eines Fixpunktes bei driftendem Systemparameter λ





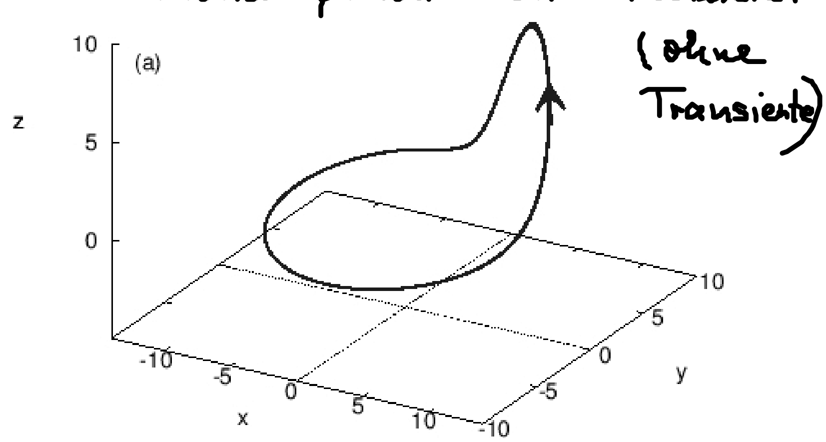
- robust gegen Rauschen $D\xi_{1,2}(t)$:



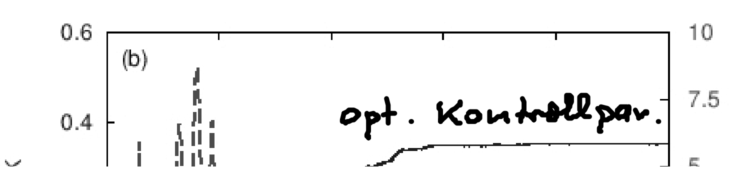
Stabilisierung eines instab. period. Orbits

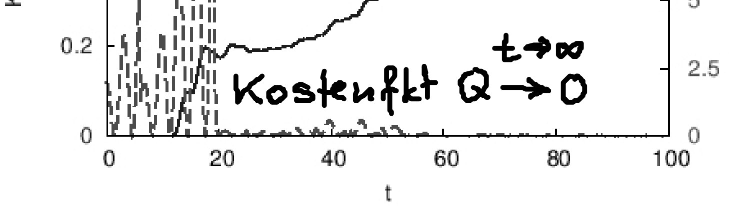
Rössler - System (chaotisch)

instabiler period. Orbit stabilisiert



$\tau = 5.9.. = T_{UPO}$





2.4 Quantenkontrolle

Howard Wiseman & G. Milburn: Quantum Measurement and Control (Cambridge U Press 2010)

5th Int. Conf. on Physics and Control (PhysCon 2011, Leon):
"Bringing quantum jumps under control"

$\boxed{\text{Adaptive Quantenmessung}}$

Rückkopplungskontrolle

$\boxed{\text{SFB 910}}$

Vortrag H. Wiseman: TU Berlin, Mi 7.12.2011 16:00
"How many bits does it take to track an open quantum system"

R. Karasik & H.M. Wiseman: PRL $\underline{106}$, 020406 (2011)