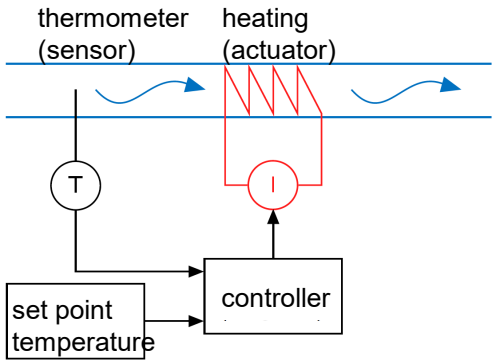
Feed Backward Makes the Difference

A Short Introduction to Control Engineering and to Wastewater Treatment

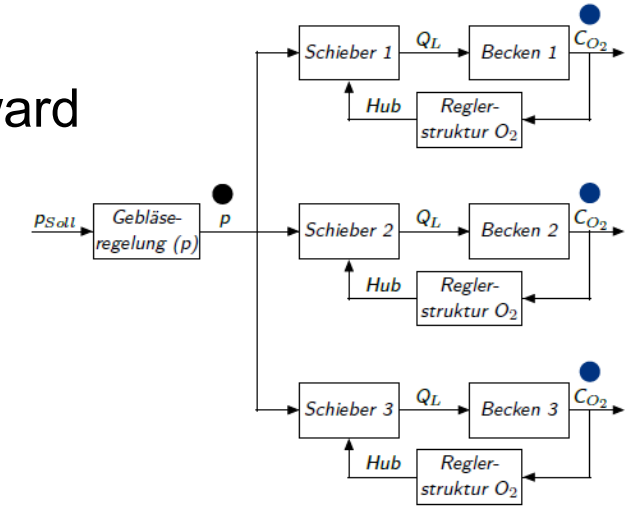
IfU Research Speed-Dating 2019, Daniel Braun, LUIW

Feed Forward and Feed Backward Control

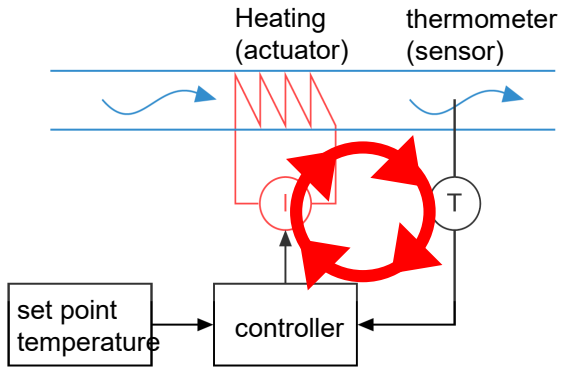
Feed Forward Control



Control Structurs
Combinations of feed forward and feed backward



Feed Backward Control

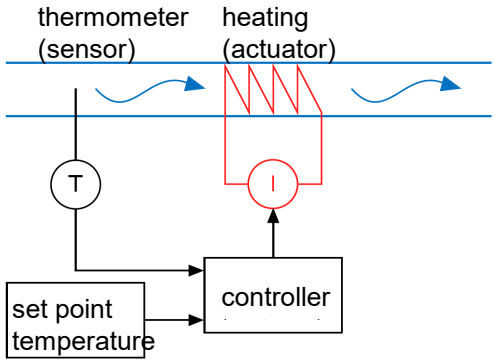


Feed Backward Control creates new properties

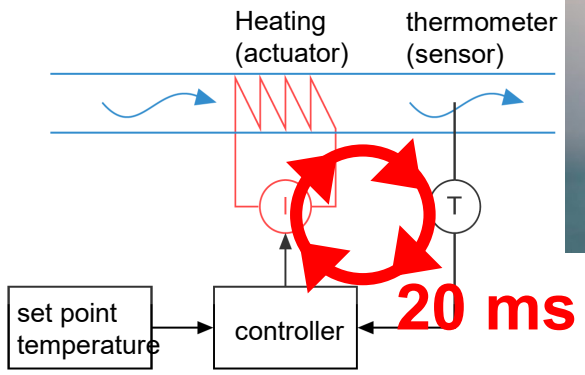
- robust and stable control of set point within the stability limits
- Oscillations outside stability limits
- Difficult to distinguish cause and effect
- ….

Feed Forward and Feed Backward Control

Feed Forward Control



Feed Backward Control



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By Josh Sorenson - https://www.pexels.com/photo/quadcopter-flying-on-the-skey-1034812/ archived on 20 May 2018 at the Wayback Machine, CC0, https://commons.wikimedia.org/w/index.php?curid=69306462

Feed Backward in Wastewater Treatment: Why is the Activated Sludge Process that Robust?

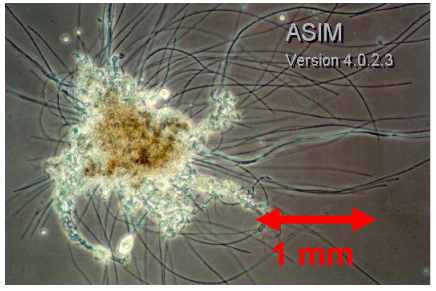
https://www.shutterstock.com/image-illustration/3d-render-atom-structure-carbon-isolated-550082404
https://en.wikipedia.org/wiki/Water
https://de.wikipedia.org/wiki/Desoxyribonukleins%C3%A4ure
https://en.wikipedia.org/wiki/Cell_(biology)

Feed Backward in Wastewater Treatment: Why is the Activated Sludge Process that Robust?

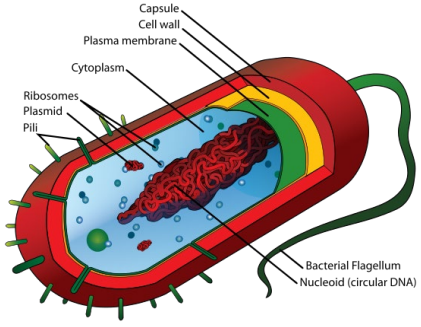
Due to feed backward loops invented by nature and enhanced by numerus observations of environmental engineer

Murray Gell-Mann: The Quark And The Jaguar: Adventures in the Simple and the Complex
Robert B. Laughlin: A Different Univeerse: Reinventing Physics from the Bottom Down

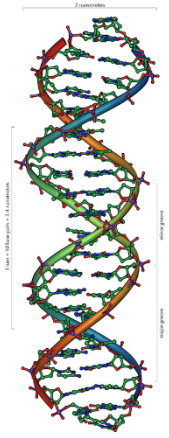
activated sludge tank



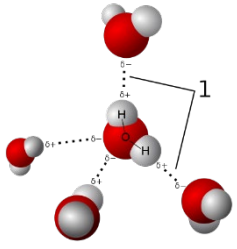
biological floc with mixed cultures



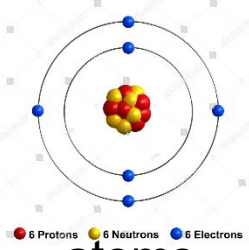
prokaryotic cell with organells



macromolecular structures



molecules



atoms

https://www.shutterstock.com/image-illustration/3d-render-atom-structure-carbon-isolated-550082404
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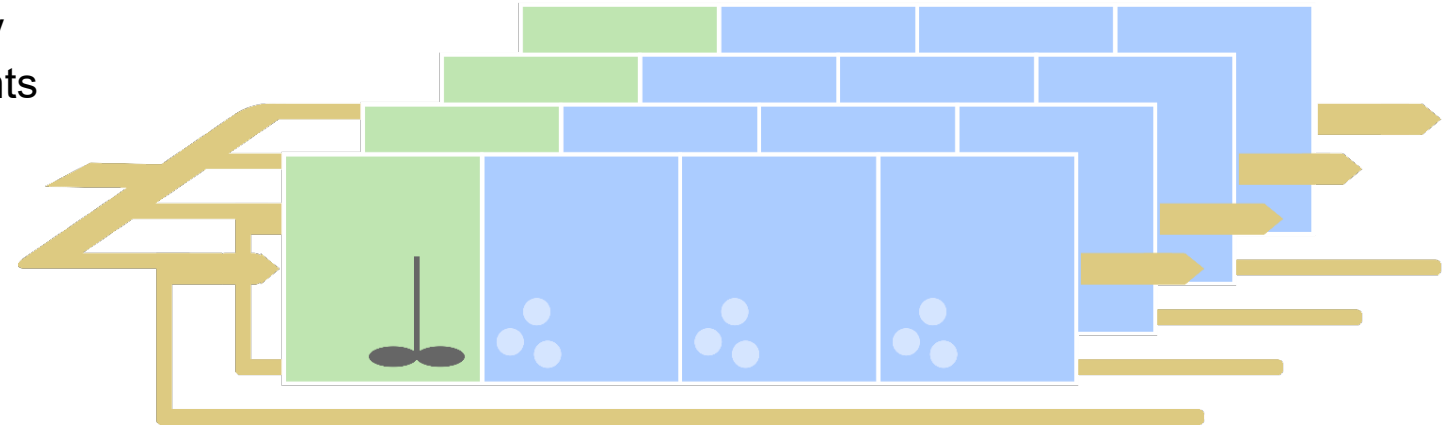
From Static to Dynamic Control of WWTP

Variation Input

- Diurnal variations
- Weekly variations
- Yearly variations
- Temperature
- Rain events
- Industry
- Accidents

Optimization parameters

- Distribution of load
- Hydraulic, mixing
- Aeration
- Dosage of supernatant liquor
- Sludge age
- Return sludge
- Internal
- Recirculation
- Flocculants
- Sewer management
- …

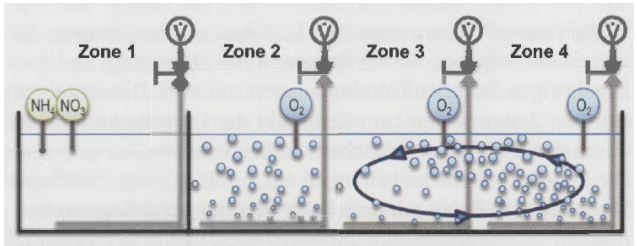


Optimization goals

- Reliability of operation
- COD degradation
- Nitrification
- Denitrification
- Nitrite reduction
- Phosphorus reduction
- Energy consumption
- Flocculants dosage
- Laughing gas reduction
- Reduction of Micropollutants
- …

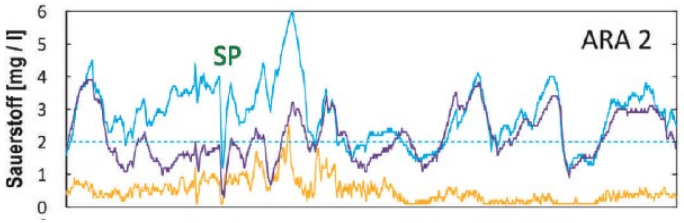
Challenges and Solutions for Dynamic Control (incomplete)

Large scale turbulence, incomplete mixing

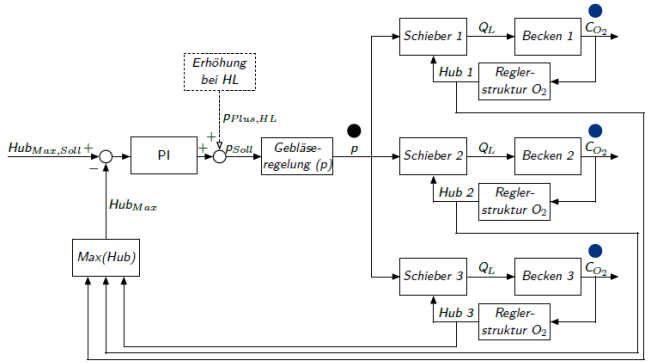


- Reactor cascade with baffles and stirrers

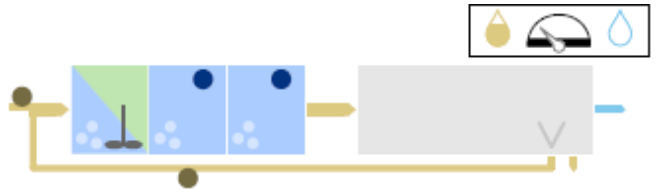
Instable controllers MiMo-Problems



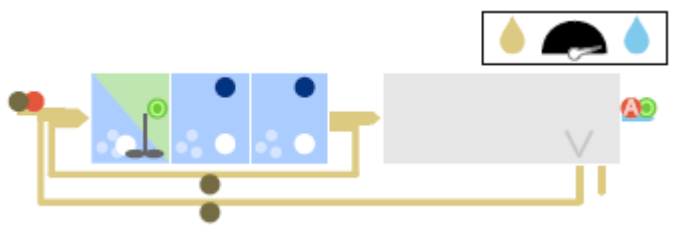
- Optimized control structures



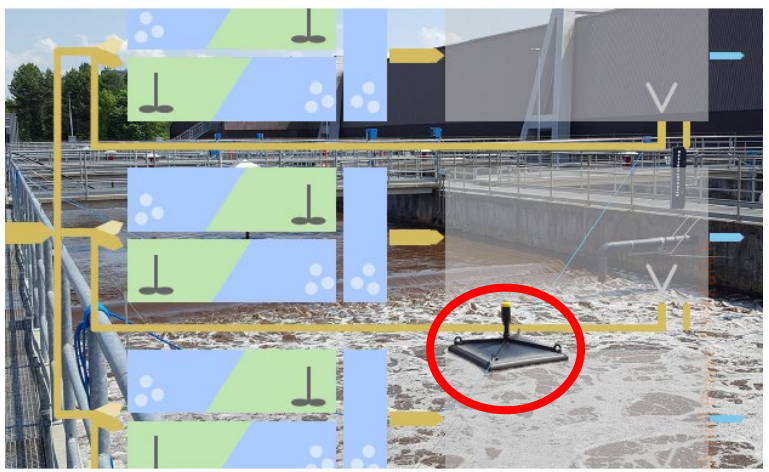
Complex (ASM)-models Limited information about process



- Simplify models to the max
- Sensor networks to determine the state of the plant



Guideline for Dynamic Control of WWTP



Dynamische Regelung von Abwasserreinigungsanlagen

Leitfaden zur dynamischen Prozessregelung und Prozessüberwachung

2019

ETH zürich

Impressum

Projektteam
Daniel Braun, ETH Zürich
Rolf Burch, Prolewa Elektro-Engineering AG
Luzia von Känel, ETH Zürich
Thomas Klaus, Gewässerschutzverband der Region Zugersee-Küssnachtersee-Ägerisee (GVRZ)
Ernst Lüdi, Stebatec AG
Markus Mendler, Hunziker Betatech AG
Alain Meyer, Hunziker Betatech AG
Daniel Pfund, Klärwerk Werdhölzli
Andreas Schaffner, Holinger AG
Reto Steinemann, Chestonag Automation AG
Urs Tobler, Rittmeyer AG
Philipp Weber, TBF + Partner AG
Martin Zeindler, BGG Engineering AG

Prof. David Zogg, Fachhochschule Nordwestschweiz
Prof. Eberhard Morgenroth, ETH Zürich

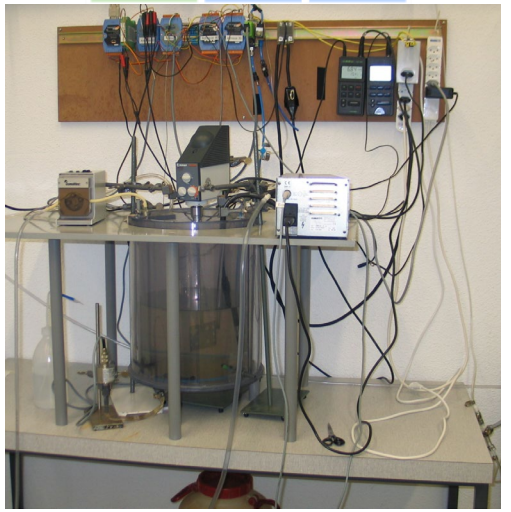
Autoren
Daniel Braun, Philipp Weber, Luzia von Känel

Herausgeber
Verband Schweizer Abwasser- und Gewässerschutzfachleute
Association suisse des professionnels de la protection des eaux
Associazione svizzera dei professionisti della protezione delle acque

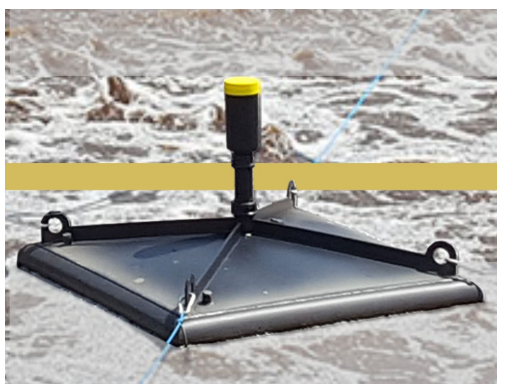
Gestaltung
Philipp Weber, Luzia von Känel

Bezugsquelle
VSA, Europastrasse 3, Postfach, CH-8152 Glattbrugg,
Telefon 043 343 70 70, sekretariat@vsa.ch, www.vsa.ch

DyRPA – Dynamische Regelung & Prozessüberwachung in der Abwasserreinigung



We estimate a 30% increase in capacity, compared to average Swiss WWTP with moderate investments.



https://luiw.ethz.ch/projekte/dyrpa.html