Data treatment models for dynamic simulation: application to sensor models

WWWest09

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Scope

1. Introduction
2. Data treatment models
3. Sensor models
4. Examples
5. Conclusion

1. Introduction

Need to improve/optimise system performance in WWTP

Modeling is one approach

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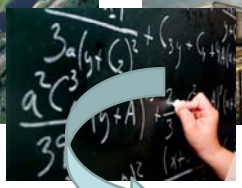
1. Introduction



Process engineer

Modeler

Operator

Dynamic models

Need to make data treatment (e.g. adding realism to the signals, filtering, data analysis…)

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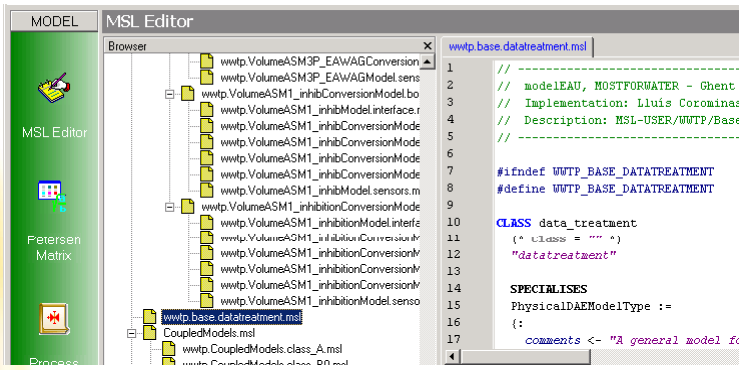
2. Data treatment models

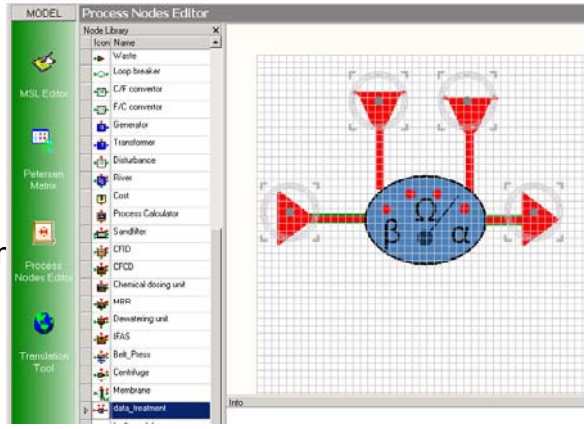
New class: ***Datatreatment***



2. Data treatment models

New node:

Data from m



2. Data treatment models

New classes:

- Noise
- Saturation
- Sample and hold
- First order response
- Delay

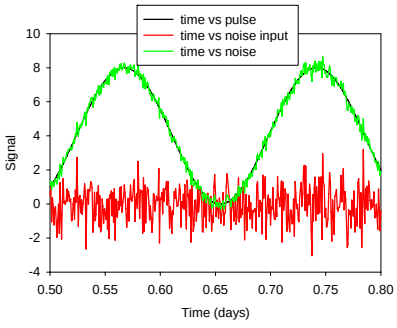
2. Data treatment models

Reality

Noise

Model

Noise (nl=0.025 * ymax)
Normally distributed
random



$$y(t) = u(t) + noise(t) \cdot Noise\_level \cdot y_{\max}$$

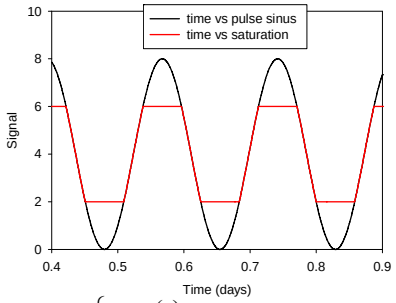
2. Data treatment models

Reality

e.g. Measuring range

Model

Saturation (y_{min}, y_{max})



$$y(t) = \begin{cases} u(t) > y_{max} : y_{max} \\ y_{min} \le u(t) \le y_{max} : u(t) \\ u(t) < y_{min} : y_{min} \end{cases}$$

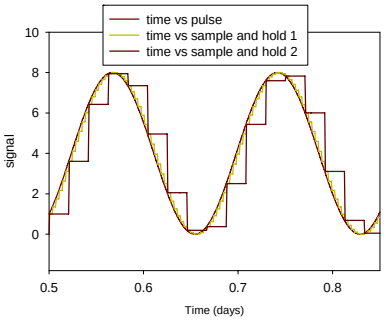
2. Data treatment models

Reality

e.g. Measuring interval

Model

Sample and hold
(zero order hold)



y(t)=u(t_{sample}, t_{sample} = floor(t/ T_interval))

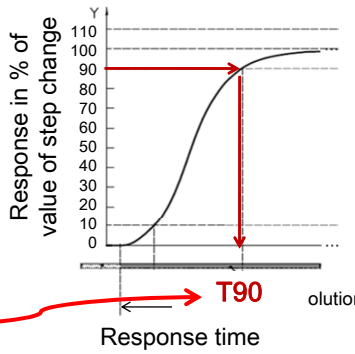
2. Data treatment models

Reality
e.g. Resp time, filter

Model
Linear transfer function

$$G_S(s) = \frac{y(s)}{u(s)} = \left(\frac{1}{1 + Tau \cdot s} \right)^n$$

From the 15839 ISO standard

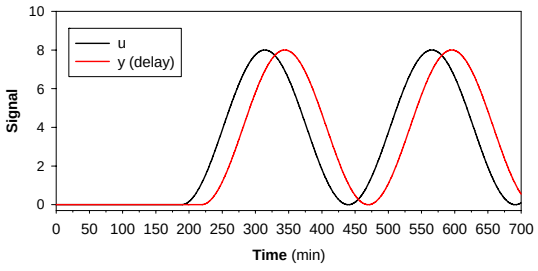


2. Data treatment models

Reality
Delay

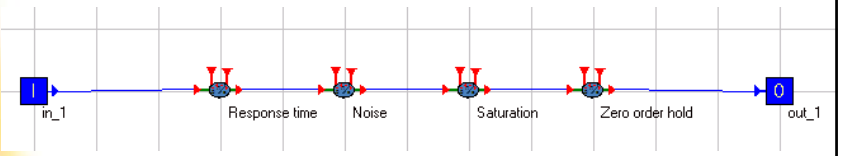
Model

$$y(t) = u(t - t\_delay)$$



2. Data treatment models (coupling)

- Flexibility to combine and couple different data treatment models



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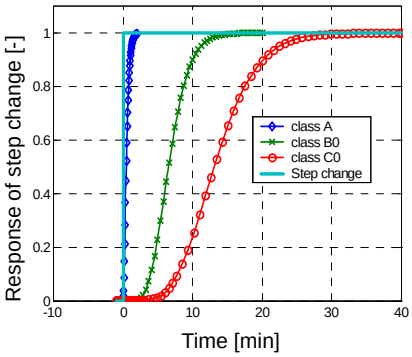
3. Sensor models - classification

According to Rieger et al. (2003)

Sensor classes	Response time [min]	Measuring interval [min]
Class A	1	0
Class B_0	10	0
Class B_1	10	5
Class C_0	20	0
Class C_1	20	5
Class D	-	30



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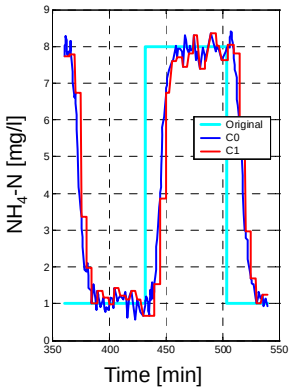

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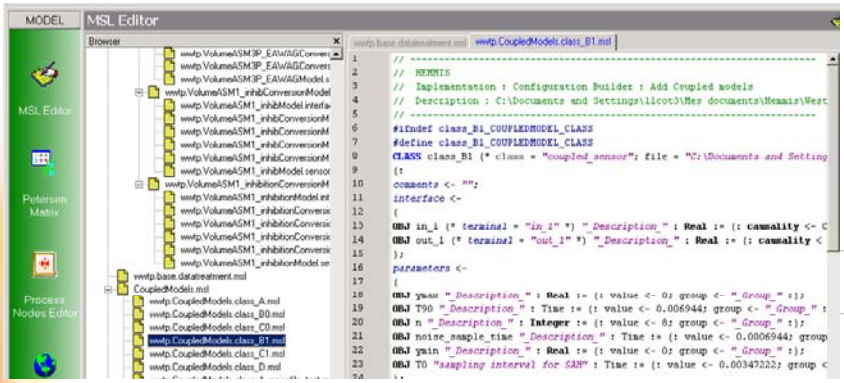
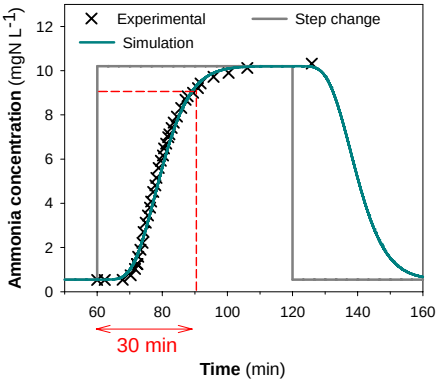


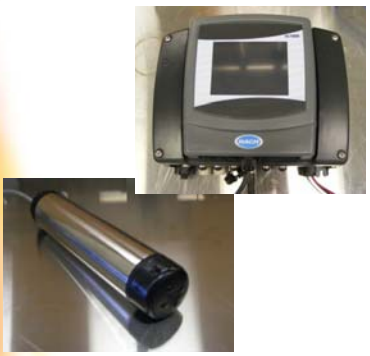
4. Examples (modeling response time)

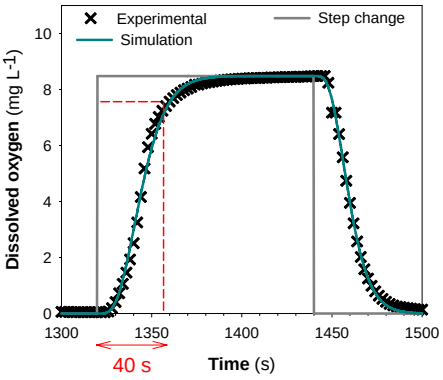
- Ammonia sensor



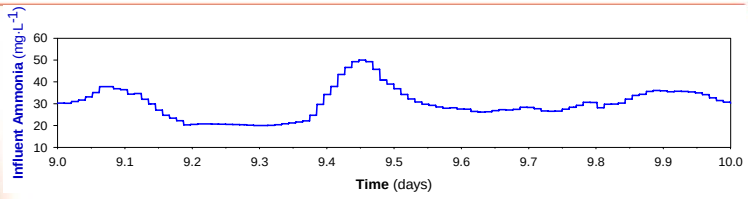
4. Examples (modeling response time)

- DO sensor





4. Examples (dynamic simulations)



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Lagacé E., Corominas Ll., Vanrolleghem P.A. and Rieger L. (2009) Improving design of measuring and control systems by introducing sensor models into dynamic WWTP simulation. ICA Newsletter, April 2009.

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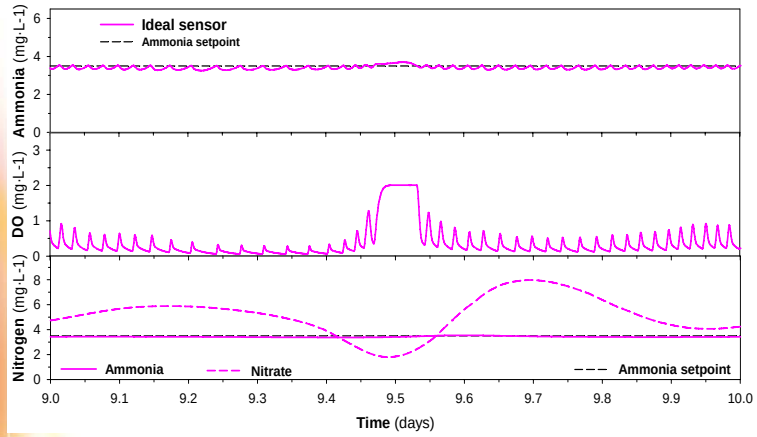
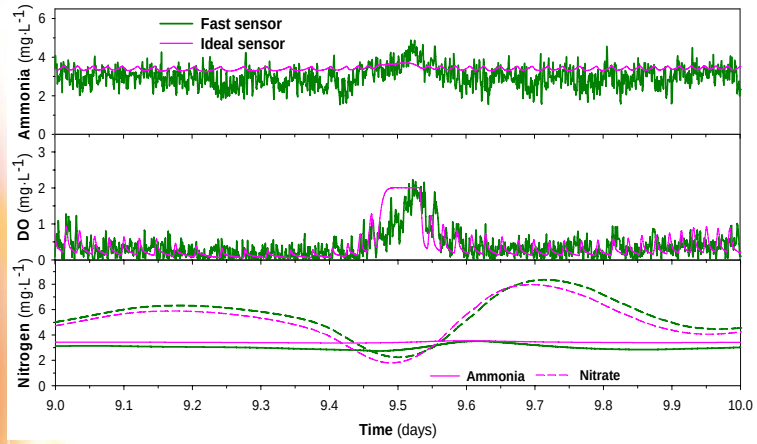


REACTOR (sensor output)

EFFLUENT (true value)

4. Examples (dynamic simulations)



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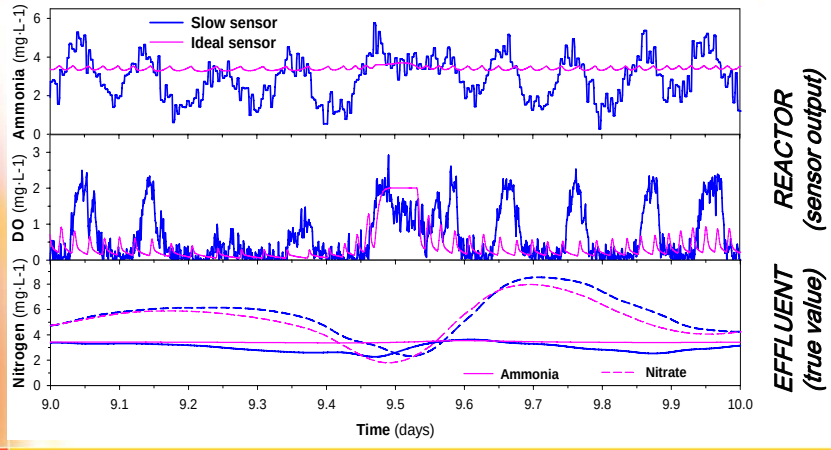
4. Examples (dynamic simulations)



5. Conclusions

- Data treatment models can now be used in dynamic simulations
  - Realistic sensor models
  - Realistic actuator models (start-up of pump, …)
  - Data filtering
  - On-the-fly data analysis (e.g. moving average)

Acknowledgments

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