Sensor based actuation of water samplers in wireless sensor networks

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Intro

- Hydrologists focus on linking catchment properties, hydrological processes and stream water dynamics. Fig. 1
- Sampling | off-site analysis of water samples in the lab, e.g. stable isotopes, nutrients, pollutants etc. Fig. 1
- Sensing | in-situ wireless sensor network (WSN) provides proxy data, e.g. electrical conductivity (EC) for optimized water sampling. Fig. 1

Problem 1: Storm event dynamics are badly sampled — especially the rising limb of the hydrograph — as most sampling schemes are static (threshold based triggering, fixed sampling intervals). Fig. 1

Problem 2: Expert knowledge has to be automated: outlier detection, outlier correction, event detection, variable sampling intervals. Fig. 2

Goals & research focus

- Smart automated sampling of hydrological events. Fig. 1
- Adequate coverage of the rising limb of the hydrograph. Fig. 1
- Using WSN proxy data to trigger water sampling. Fig. 2
- Integrating expert knowledge in control algorithms. Fig. 2
- Optimized water sampling at times with high signal dynamics. Fig. 1

Approach and set-up

- Set-up of a wireless sensor network (WSN) for monitoring and sampling of (ground)water. Fig. 3a
- WSN-node with electrical conductivity (EC) sensor-chain in well R 042, with an embedded actuator (water sampler) in well R061. Fig. 3b
- 4-Step proxy data processing by a control algorithm: (a) outlier detection, (b) outlier correction, (c) event detection and (d) sampler actuation. Fig. 3b
- Geological cross-section at test site River Thur, sampling of aquifer in well R 061, EC sensors in multiple depth in R 042 and R 060. Fig. 3c

Approach & set-up

Fig. 3a

Fig. 3b

Fig. 3c

Fig. 3d

Results & challenges

- Control algorithms are sensitive to time generation in wireless sensor networks (WSN).
- Outlier detection procedures have to evolve to provide robust event detection. Fig. 2, Fig. 4
- Static triggered sampling is outlier sensitive and inflexible. Fig. 5
- Dynamic triggering samples the rising limb of the hydrograph significantly better than static triggered sampling. Fig. 5
- Dynamic sampling allows highest flexibility, e.g. adaptive sampling intervals, where each sample is individually triggered based on streaming proxy data. Fig. 5

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- Open PhD student position, for details see http://www.geo.uzh.ch/en/units/h2k/about-us-staff/open-positions

Fig. 4 Comparison of different outlier detection algorithms (median vs probabilistic filter).

Fig. 5 Comparison of different control algorithms with experts “ground truth” best sampling reference using EC proxy data from well R 042.