EnviroInfo 2007 (Warschau)
Environmental Informatics and Systems Research

New Methods including Picture Processing for Hydro-Meteorological On-Line Data Acquisition

Christian Kollmitzer[1], Paul Skritek[1], Kurt Woletz[1], Hermann Stadler[2]

Abstract

Early warning systems, quality control networks and sustainable protection of drinking water resources became more and more important as a main task of water resources management. They heavily rely on on-line measurements, which mostly are automated. Nevertheless the quality of the measured data can be increased by an integrated Quality Management System, including also the field measurement devices into a complete chain of quality traceability.
To increase the data reliability alternative measuring methods have to be evaluated. In our prototype development staff gauge images are digitally processed to achieve a second value for the actual water-level. If the both detected water levels are different, an alarm is generated or remote configuration procedures are performed. The system is a contribution to an integrated Quality Management Tool, allowing retracing the complete chain of measuring value acquisition. Low Earth Orbit Satellites then allow worldwide “nomadic” on-line data-communication from otherwise inaccessible regions. Their combination with plausibility tests in the run-up to the database enables us to accept the great challenge of "real-time" supervision of the quality of the measurements.

1. Water Level Measurement System

The gauge height is a most important parameter for hydrogeological investigations. Typical Measurement devices are differential pressure probes, pneumatic probes or radar devices, which require periodical control measurements. Usually this is realized by local service persons. In secluded areas, during wintertime or in vast regions, this can be impossible.

Therefore we are developing a system to generate control measurements automatically from pictures of a staff gauge. System backbone is a near real time bidirectional LEO satellite communication link. From the measuring station (MS) in the field, periodical measurements of the water level (for instance with a pressure probe) and others, including quality parameters, are transmitted to a Central Monitoring Station (CMS) and after several plausibility tests, these values are stored in a data base (Figure 1).

Additionally pictures of a staff gauge are shot. Image processing for automatically extraction of the water level is done in the camera. These control values are transmitted to the CMS. In a next step also the pictures will be transmitted via satellite to the CMS to retrace the whole procedure of water-level measurements and the integrated quality management system.

Data from the MS is stored in a database as "original values" within the CMS. Plausibility tests can be conduced automatically. If several values are detected as "false value" (like spikes) a second quality level for "automatically corrected values" is created ("original values" are never changed or deleted). Both values are available for automated comparison. In case of deviations, different measures are possible: Alarm messages in the CMS, GSM based information to a local service team, a query to the system to verify the values, or a remote configuration of the MS. As the whole system works in "near-real-time", short response times are possible.

[1] University of Applied Sciences FH Technikum Wien, Höchstädtplatz 5, A-1200 Wien, Tel.: (+43 1) 33 34 077; e-mails: christian.kollmitzer@technikum-wien.at; paul.skritek@technikum-wien.at; kurt.woletz@technikum-wien.at
[2] Joanneum Research, Inst. of Water Resources Management – Hydrogeology and Geophysics, Elisabethstr. 16, A-8010 Graz, Tel.: (+43 316) 876 1326; e-mail: hermann.stadler@joanneum.at

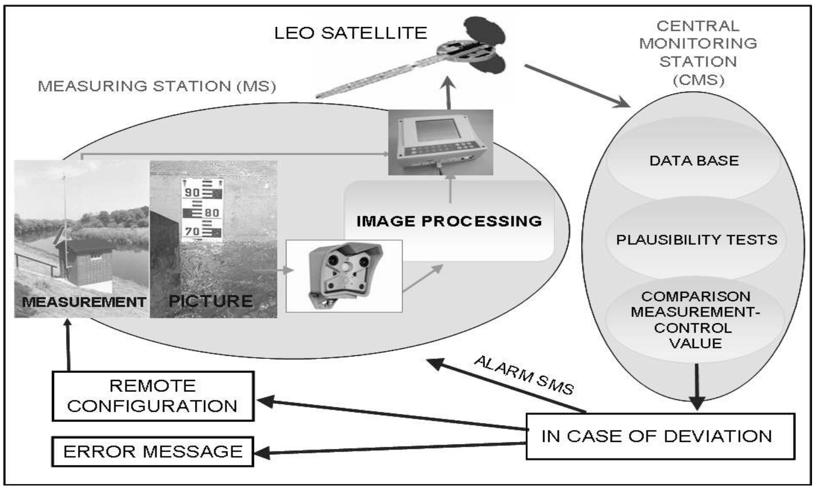

Figure 1: Scheme of data flow for quality control of gauge height

2. Image Processing

A smart camera with a built-in signal processor takes pictures in appropriate resolution and runs image processing algorithms to detect the water-level.

A specifically designed staff gauge is used. The pattern of the staff gauge has to be recognizable by people as well as by an image processing system. The camera (including additional illumination) is positioned on a gibbet for a constant and reliable distance and angle in respect to the staff gauge.

The algorithms for water-level extraction consist of edge and line detection, gray shade compensation, distortion, object recognition and corner detection. They are developed in MATLAB and in C and are tested with still pictures and videos to evaluate also small variations in illumination, picture noise and water surface movements.

Figure 2 shows the situation in clear water and with a calm surface. The developed robust algorithm provides level detection also with moving water surface and with muddy water.

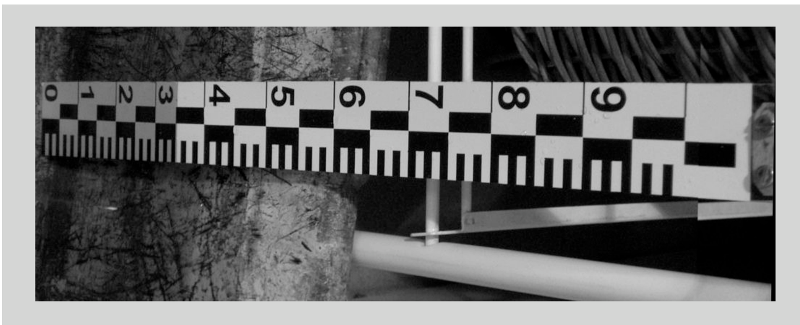

Figure 2: Staff gauge in clear water

3. Measuring Station

The measuring system consists of a specific staff gauge, a smart camera and a data logger (figure 3). The camera is activated by the data logger, takes a picture, calculates the water level and sends the value via a serial interface to the data logger. The data logger is connected to a satellite transmission system and transfers the values to a central station CMS (Stadler, 2003; Heine, 2005). Comparison of the two measured level values (by conventional means vs. image processing) is performed either in the data logger or in the CMS. Furthermore the CMS can initiate an extra image transfer to allow an evaluation of the situation at the measuring site.

Figure 3: Components of the measuring station

4. Satellite Data Transmission

To avoid expensive infrastructure networks and to overcome coverage problems with land-based mobile systems (GSM/GPRS/UMTS) or Geostationary Earth Orbit satellites, LEO-Satellites (Low Earth Orbit) are preferable (Skritek, 2004; Stadler, 2004; Heine, 2005; O'Brien, 2005; Ruch, 2006). Three commercial LEO-systems, ORBCOMM, IRIDIUM, GLOBALSTAR, were extensively evaluated, including long-term coverage and signal-quality tests. IRIDIUM proved as premium choice for data bulk traffic (pictures) of several kilobytes at acceptable costs and by using "AT"-control commands, which allows implementations compatible to GSM/GPRS-modems. 24-h coverage tests proved a signal level quality of "60% or better" for 97,6% of time and only one minute no "satellite in view".

Mobile transmission-boxes as well as ftp-servers were implemented and file transfers accomplished. Next steps will extend coverage and transmission tests (e.g., signal attenuation by vegetation) as well as integration of the IRIDIUM feature into a commercial Linux-based data-logger (Waterpool, 2007).

Figure 4: IRIDIUM and GLOBALSTAR test-boxes in operation

Bibliography

Heiner, W. et.al. (2005): Online System for Hydro-Meteorological Data gathered via LEO-Satellite Transmission. Proc. 19th Int. Conf. EnviroInfo2005, Brno.

O'Brien, J.R. (2005): Near Term Satellite Communications for Disaster Recovery. National Conference on Emergency Communications Systems 2005, Washington.

Ruch, Ch., et.al. (2006): New technologies for more efficient flood management systems. Proc. 20th Int. Conf. EnviroInfo2006, Graz.

Rüppel, U. and T. Gutzke, P. Göbel, G. Seewald (2006): Groundwater Risk Management Using Data Logger for an Automated Information Retrieval. Proc. 20th Int. Conf. EnviroInfo2006, Graz.

Skritek, P., Stadler, H. (2004): Networking of Automated Event-Sampling Hydro-Meteorological Measuring Sites using LEO-Satellite Communication. Proc. 18th Int. Conf. EnviroInfo2004, Geneva.

Stadler, H., P. Skritek. (2003): "Remote Water Quality Monitoring 'on-line' using LEO Satellites." Wat. Sci. & Tech. 47(2): 197-204.

Waterpool (2007): http://www.waterpool.org, last visit May 5th, 2007.