Geophysical Research Abstracts,
Vol. 11, EGU2009-6048, 2009
EGU General Assembly 2009

Monitoring of slope-instabilities and deformations with Micro-Electro-Mechanical-Systems (MEMS) in wireless ad-hoc Sensor Networks

C. Arnhardt, T.M. Fernández-Steeger, and R. Azzam

Department of Engineering Geology and Hydrogeology, RWTH Aachen University, Germany (arnhardt@lih.rwth-aachen.de)

In most mountainous regions, landslides represent a major threat to human life, properties and infrastructures. Nowadays existing landslide monitoring systems are often characterized by high efforts in terms of purchase, installation, maintenance, manpower and material. In addition (or because of this) only small areas or selective points of the endangered zone can be observed by the system. Therefore the improvement of existing and the development of new monitoring and warning systems are of high relevance. The joint project "Sensor based Landslide Early Warning Systems" (SLEWS) deals with the development of a prototypic Alarm- and Early Warning system (EWS) for different types of landslides using low-cost micro-sensors (MEMS) integrated in a wireless sensor network (WSN). Modern so called Ad-Hoc, Multi-Hop wireless sensor networks (WSN) are characterized by a self organizing and self-healing capacity of the system (autonomous systems). The network consists of numerous individual and own energy-supply operating sensor nodes, that can send data packages from their measuring devices (here: MEMS) over other nodes (Multi-Hop) to a collection point (gateway). The gateway provides the interface to central processing and data retrieval units (PC, Laptop or server) outside the network.

In order to detect and monitor the different landslide processes (like fall, topple, spreading or sliding) 3D MEMS capacitive sensors made from single silicon crystals and glass were chosen to measure acceleration, tilting and altitude changes. Based on the so called MEMS (Micro-Electro-Mechanical Systems) technology, the sensors combine very small mechanical and electronic units, sensing elements and transducers on a small microchip. The mass production of such type of sensors allows low cost applications in different areas (like automobile industries, medicine, and automation technology). Apart from the small and so space saving size and the low costs another advantage is the energy efficiency that permits measurements over a long period of time. A special sensor-board that accommodates the measuring sensors and the node of the WSN was developed. The standardized interfaces of the measuring sensors permit an easy interaction with the node and thus enable an uncomplicated data transfer to the gateway. The 3-axis acceleration sensor (measuring range: +/- 2g), the 2-axis inclination sensor (measuring range: +/- 30°) for measuring tilt and the barometric pressure sensor (measuring rang: 30kPa – 120 kPa) for measuring sub-meter height changes (altimeter) are currently integrated into the sensor network and are tested in realistic experiments. In addition sensor nodes with precise potentiometric displacement and linear magnetorestrictive position transducer are used for extension and convergence measurements. According to the accuracy of the first developed test stations, the results of the experiments showed that the selected sensors meet the requirement profile, as the stability is satisfying and the spreading of the data is quite low. Therefore the jet developed sensor boards can be tested in a larger environment of a sensor network. In order to get more information about accuracy in detail, experiments in a new more precise test bed and tests with different sampling rates will follow.

Another increasingly important aspect for the future is the fusion of sensor data (i.e. combination and comparison) to identify malfunctions and to reduce false alarm rates, while increasing data quality at the same time. The correlation of different (complementary sensor fusion) but also identical sensor-types (redundant sensor fusion) permits a validation of measuring data. The development of special algorithms allows in a further step to analyze and evaluate the data from all nodes of the network together (sensor node fusion). The sensor fusion contributes to the decision making of alarm and early warning systems and allows a better interpretation of data.

The network data are processed outside the network in a service orientated special data infrastructure (SDI) by standardized OGC (open Geospatial Consortium) conformal services and visualized according to the requirements

of the end-user.
The modular setup of the hardware, combined with standardized interfaces and open services for data processing allows an easy adaption or integration in existing solutions and other networks. The Monitoring system described here is characterized by very flexible structure, cost efficiency and high fail-safe level. The application of WSN in combination with MEMS provides an inexpensive, easy to set up and intelligent monitoring system for spatial data gathering in large areas.