Geophysical Research Abstracts
Vol. 18, EGU2016-4470, 2016
EGU General Assembly 2016

Development of an Arduino-based electrical impedance tomography system with application to dam internal erosion detection

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Electrical Impedance Tomography (EIT) is a technique for the imaging of the electrical properties of conductive materials. In EIT, the spatial distribution of the electrical resistivity or electrical conductivity within a domain is reconstructed using measurements made with electrodes placed at the boundaries of the domain. Data acquisition is typically made by applying an electrical current to the object under investigation using a set of electrodes, and measuring the developed voltage between the other electrodes. The tomographic image is then obtained using an inversion algorithm.

This work describes the implementation of a simple and low cost 3D EIT measurement system suitable for laboratory-scale studies. The system was specifically developed for the time-lapse imaging of soil samples subjected to erosion processes during laboratory tests. The tests reproduce the process of internal erosion of soil particles by water flow within a granular media; this process is one of the most common causes of failure of earthen levees and embankment dams. The measurements needed strict requirements of speed and accuracy due to the varying time scale and magnitude of these processes.

The developed EIT system consists of a PC which controls I/O cards (multiplexers) through the Arduino microcontroller, an external current generator, a digital acquisition device (DAQ), a power supply and the electrodes. The ease of programming of the Arduino interface greatly helped the implementation of custom acquisition software, increasing the overall flexibility of the system and the creation of specific acquisition schemes and configurations. The system works with a multi-electrode configuration of up to 48 channels but it was designed to be upgraded to an arbitrary large number of electrodes by connecting additional multiplexer cards (> 96 electrodes). The acquisition was optimized for multi-channel measurements so that the overall time of acquisition is dramatically reduced compared to the single channel instrumentation.

The accuracy and operation were tested under different conditions. The results from preliminary tests show that the system is able to clearly identify objects discriminated by different resistivity. Furthermore, measurements carried out during internal erosion simulations demonstrate that even small variations in the electrical resistivity can be captured and these changes can be related to the erosion processes.