Inversion of Pulse Induction and Continuous Wave Metal Detector Data

J. Lange*[1], T. Hanstein[2], and S. L. Helwig[1]

[1] Institute of Geophysics and Meteorology, University of Cologne, Germany

[2] HarbourDom GmbH, Cologne, Germany

Metal detectors transmit electromagnetic pulses or harmonic alternating electromagnetic fields, which cause induction currents inside the metal parts. The electromagnetic fields are measured and turned into a acoustic, optic or vibration signal, which is proportional to the amplitude of the induced voltages. A Further analysis of the measured fields is not done. The project network " HuMin/MD Metal detectors for Humanitarian Demining: Development potentials for data analysis and measurement techniques" (http://www.humin-md.de) funded by the German Federal Ministry of Education and Research (BMBF) evaluates the potential of new mathematical methods that work with measuring data from commercial off-the-shelf metal detectors. The network consists of eleven institutes working on 3D-imaging, signal analysis, research on the soil influence and the measurement technique. The aim is to reduce the false alarm rate when using metal detectors for humanitarian demining by extracting as much information as possible out of the signal.

The approach presented here is the inversion of the signal by using fast semi-analytical simulations for simple-shaped objects. Our first object was a metal sphere, because the induced voltages are easy and fast to simulate. The response was measured in the laboratory by moving the metal detector with a scanner over different metal spheres located either in air or in soil. For an accurate simulation it was also necessary to consider the exact design of the transmitter and receiver coils. The measured and calculated voltages for the two used frequencies were almost the same and radius, horizontal position and depth determined by the inversion conform well with the real parameters. Even electrical conductivity and magnetic permeability had reasonable values. In the next step we measured the response of three spheres and inverted the data with a three-sphere-model. The inversion results were also reasonable. Even the results for some objects with a more complex geometry like bullets or simple mine surrogates delivered a good estimate of the size, depth and material of the objects.

The inversion of the time domain metal detector data was more difficult. The receiver coil is not differential wound and also a time series is recorded, therefore the measurement is more sensible to noise. At the metal detector itself there are metal screws inducing a additional signal, which must be considered. For the modeling the exact knowledge of the coil diameter, the used filters, the pulse length and the amplifiers was important, but not always easy to get. Diameter and pulse length were measured in the laboratory, but the value of amplifiers and filters were only estimated. At the moment it is possible to simulate the induced voltage and get a good matching of the measured data. Because of the mentioned difficulties the inversion results are not as accurate as in frequency domain. Especially the determination of the ground conductivity delivers higher values then expected.

Our next step besides improving the time domain inversion, is the implementation of a fast simulation of a ring and a ellipsoid. First tests are quite promising.