PHASE ANGLE BASED CLUTTER REDUCTION AND 2D IMAGING USING DATA FROM A COMMERCIAL DIFFERENTIAL TWO FREQUENCY EMI SYSTEM

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The EPFL and the VUB have been investigating for some time the response of metal detectors for humanitarian demining (1), in particular CW systems. A simple circuit model as well as a more complete model (full response of a sphere in the field of a circular coil) point to the possibility, as has also been stressed by others, of identifying some metallic objects based on their characteristic phase response. In addition, the phase shift of the received signal turns out to be a continuous function of the object size; this leads to the idea of imposing a "phase threshold" in order to reduce the amount of detected clutter. This approach is less ambitious than object identification, but is likely to be more robust, and to work best when looking for larger metallic objects such as those contained in non minimum-metal mines (e.g. PMN, PMN2) or UXO.

A first series of measurements were carried out using a Foerster Minex 2FD differential two-frequency metal detector. We have recorded the detector's in-phase (I) and quadrature-phase (Q) component at each frequency, as well as the difference of the two quadrature-phase components and the final audio signal. The latter is here directly derived from the difference signal. (Series of parallel) Linear scans have been carried out with a high density of points in the scan direction. The collection of data as a function of movement allows to analyse the data in the complex, or impedance, plane (I-Q). This method was inspired from Non Destructive Testing, and puts in evidence global object properties rather than only local ones (2). Results are presented for mines and mine components, as well as a few reference objects and clutter, buried in an indoor test system varying different parameters (material type, object distance, axial offset, orientation in the horizontal plane, etc.). The limits of such discrimination/identification approaches are also briefly outlined.

The parallel scans were also used to obtain bidimensional “images” of some metallic objects. Their resolution is limited by the detector’s size, but can be ameliorated with image processing techniques such as deconvolution with the detector’s intrinsic response, or PSF (Point Spread Function). The PSF, which is a function of the object’s depth, can be obtained either theoretically (modelling) or experimentally via direct measurements on small objects for example (3). Some example images are shown and the limits of this approach, such as sensitivity to noise and to ground inhomogeneities, are detailed.

(1) C. Bruschini, “Metal detectors in civil engineering and humanitarian de-mining: overview and tests of a commercial visualising system”, INSIGHT - Non-Destructive Testing and Condition Monitoring 42(2), pp. 89-97, Feb. 2000.

(2) P. Szyngiera, “A Method of Metal Object Identification by Electromagnetic Means”, in Proc. MINE'99 (Mine Identification Novelties Euroconference), pp. 155-160, Florence, Italy, Oct. 1-3, 1999.

(3) L. Merlat, M. Acheroy, “Improving quality of information from metal detectors”, in Proc. 1999 ARIS Technical Workshop on Ground Survey for Humanitarian Demining, Brest, France, 26-27 Oct. 1999.