Geophysical Research Abstracts
Vol. 13, EGU2011-7057, 2011
EGU General Assembly 2011

Super resolution signal processing of GPR spectra for pavement engineering applications

Andrea Benedetto (1) and Francesco Benedetto (2)

(1) University ROMA TRE, Sciences of Civil Engineering, Rome, Italy (benedet@uniroma3.it, 0039.06.57333441), (2) Digital Signal Processing, Multimedia, and Optical Communications Lab., Dept. of Applied Electronics, University of ROMA TRE, via della Vasca Navale 84, 00146 Rome, Italy. Tel. +39 06 57337004; fax: +39 06 57337026; e-mail: fbenedet@uniroma3.it

Ground Penetrating Radar (GPR) is, actually, one of the most advanced technology in civil engineering applications (e.g. in road pavement inspection). Actually, the pavement damages and defects so as the loss of mechanical properties in the subgrade represent one of the most crucial problem for safety. One of the most relevant causes of damage is often referable to water intrusion in structural layers or clay pumping in sandy subgrade. Currently, a number of accurate techniques are used, but they are intrusive, expensive, time consuming and they give punctual information, i.e. only in the measurement site. Hence, the use of non-intrusive techniques is recommended. GPR uses radar pulses to image the subsurface. This non-destructive method uses electromagnetic radiation and detects the reflected signals from subsurface structures.

Addressing some of these issues, the scope of the paper is to show the consistency of the GPR diagnosis regarding to some of these hidden conditions. In particular, we present here a method to quantify clay intrusion in a random medium exploiting the scattering phenomena originated when the medium is investigated by a GPR radar signal. Following a recent new approach that was proposed to estimate moisture content in a porous medium without preventive calibration basing on the theory of Rayleigh scattering, we expect here to show a shift of the frequency spectrum towards lower frequencies as the clay content increases in the soil. The weak point of this analysis is the low resolution affecting the GPR spectra: in fact, the frequency of the peak in the spectrum decreases with the increasing of clay content but we need a sensible increasing of the clay content to appreciate the frequency shift. Here, we propose a method to obtain a super-resolution and high-precision signal level in the frequency domain in presence of clay. First, we show that also in presence of clay intrusion we observe a shift of the frequency spectrum towards lower frequencies. We have verified the same systematical trend also for higher order spectral moments, putting in evidence the correlation between the variance and the kurtosis of the spectrum with the amount of clay. Then, we propose a new technique that combining the response of the conventional fast Fourier transform (FFT, well known for its high-precision receiving signal level) with that of the MUSIC (multiple signal classification) algorithm, well known for its super-resolution capacity can obtain a high precision level in quantifying the frequency shift of the GPR spectrum.

Experimental results confirm the effectiveness of the proposed approach to quantify clay intrusion in soil. In fact, the proposed super resolution technique can resolve a frequency shift in the GPR spectrum for a corresponding amount of clay of about 2-3%.