Geophysical Research Abstracts
Vol. 14, EGU2012-4120, 2012
EGU General Assembly 2012

Enhancing the resolution of gpr spectra for pavement engineering applications

F. Benedetto (1) and A. Benedetto (2)

(1) Univ. of Roma TRE, Electronic Engineering, Applied Electronics Dept., Rome, Italy (fbenedet@uniroma3.it), (2) Univ. of Roma TRE,Dept. of civil engineering, Rome, Italy (benedet@uniroma3.it)

Ground Penetrating Radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This non-destructive method uses electromagnetic radiation and detects the reflected signals from subsurface structures. It can detect objects, changes in material, and voids and cracks. GPR has many applications in a number of fields. In the field of civil engineering one of the most advanced technologies used for road pavement monitoring is based on the deployment of advanced GPR systems.
One of the most relevant causes of road pavement damage is often referable to water intrusion in structural layers. In this context, GPR has been recently proposed as a method to estimate moisture content in a porous medium without preventive calibration. Hence, the development of methods to obtain an estimate of the moisture content is a crucial research field involving economic, social and strategic aspects in road safety for a great number of public and private Agencies.

In particular, a recent new approach was proposed to estimate moisture content in a porous medium basing on the theory of Rayleigh scattering, showing a shift of the frequency peak of the GPR spectrum towards lower frequencies as the moisture content increases in the soil. The weakness characterizing this approach is represented by the needs of high resolution signals, whereas GPR spectra are affected by low resolution. Hence, the rising requirement for high resolution leads to specific demands for improved prediction methods. Recently, a new technique 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 has been proposed. This combined method has been proved to obtain a high precision level in quantifying the shift of the frequency peak of the GPR spectrum. This combined method can perform a reliable coarse estimate of the (abscissa of the) frequency peak. Unfortunately, whereas resolution affecting the GPR spectra has been enhanced, we still need a sensible increasing of the moisture content to appreciate a visible frequency shift. Hence, sub-sample resolution techniques are needed to obtain a resolution better than the sample period.

Addressing some of these issues, this work proposes a sub-sample resolution technique exploiting a fast parabolic interpolator, running on three samples of the GPR spectrum in the neighborhood of the frequency peak (i.e. the coarse estimation). More in details, the new detector searches for the (abscissa of the) vertex of the parabola fitted over three GPR samples: the coarse estimate of the frequency peak, and one sample before and after this estimation. The rationale behind the new fast parabolic approach is as follows. We expect the method to obtain a finer estimation of the (abscissa of the) frequency peak because we are now interpolating a parabola in the neighborhood of the same maximum (i.e the coarse estimate), but with a narrow variance thus increasing the estimation accuracy. No noteworthy increase of computational complexity and processing throughput is required to implement the new approach. In fact, near the totality of the amount of the required computation is due to the former stage (i.e. FFT and/or MUSIC implementation to evaluate the coarse estimate of the frequency peak), and the latter logic (i.e. the interpolation function) is negligible from implementation and computational point of view.

Experimental results confirm the effectiveness of the proposed approach to evidence and quantify moisture content in soil. In fact, the proposed sub-sample super resolution technique can resolve a frequency shift in the GPR spectrum even for a corresponding amount of moisture less than 2-3%.