Detection of Buried Objects in Periodic Structures with Ground Penetrating Radar Mounted on Moving Vehicles

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The aim of this paper is the analysis and the development of algorithms capable to detect anomalies in periodic structures by using an ultra-wide-band (UWB) Ground Penetrating Radar. These inspection methods based on GPR are commonly used for surveys of civil structures like rebar underneath a road or a bridge or more recently for landmines detection along railway tracks. In these cases a radar with an array of antennae is generally mounted on a moving vehicle which allows the acquisition of radar signals at a certain velocity. In order to detect variations of the inspected area in real time it is necessary to develop quick signal processing methods also capable to account for the unavoidable variation of the background measurable with radar (e.g., period of the bars distance in the railway or the thickness of a layer in a road).

Among several possible methods available in the literature (physical model based or image processing based) we decide for the homomorphic deconvolution of radar signal based on the Cepstrum [ref 1]. This technique has been chosen according to the assumption that the received radar signal is generated by the convolution of the transmitted signal and the characteristic function of the object. To prove this assumption we synthesized signals of some buried landmines with the convolution model and we compared with the experimental one. In the case of the rebar or pipes buried in concrete layers, this assumption is still valid considering that the radar central wavelength is much comparable to the object size and the characteristic object function becomes simpler. This trial on simple objects was needed to set the algorithm parameters. Then we have simulated several cases of interest for GPR surveys like variation of object dimensions, variation of the periodic pattern, variation of the periodic buried objects lateral distance and different values of signal to noise ratio. The method included a moving window approach to calculate variations in the acquired signals and requires an initialization step (initial pattern estimation). Other methods based on Fourier Transform have also been investigated.

Finally the algorithm was applied to an experimental dataset of rebar buried in a 4 cm thick concrete layer separated by 12 cm. The signals are acquired in a bridge with a 1.5 GHz central frequency UWB radar along a distance of 7 m. The results are an average distance of rebar 15.5 cm with standard deviation 2.3 cm. A processing time of 0.5 s with acquisitions at pulse repetition frequency of 32 kHz was found to be compatible with a vehicles velocity of about 6 km/h.

REFERENCES

1. Oppenheim, A. V. and R. W. Shafer, *Digital signal processing*, Prentice Hall, London, 1975.