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Improving GPR Surveys Productivity by Array Technology and Fully Automated Processing

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The realization of network infrastructures with lower environmental impact and the tendency to use digging technologies less invasive in terms of time and space of road occupation and restoration play a key-role in the development of communication networks.

However, pre-existing buried utilities must be detected and located in the subsurface, to exploit the high productivity of modern digging apparatus. According to SUE quality level B+ both position and depth of subsurface utilities must be accurately estimated, demanding for 3D GPR surveys. In fact, the advantages of 3D GPR acquisitions (obtained either by multiple 2D recordings or by an antenna array) versus 2D acquisitions are well-known. Nonetheless, the amount of acquired data for such 3D acquisitions does not usually allow to complete processing and interpretation directly in field and in real-time, thus limiting the overall efficiency of the GPR acquisition.

As an example, the "low impact mini-trench "technique (addressed in ITU – International Telecommunication Union - L.83 recommendation) requires that non-destructive mapping of buried services enhances its productivity to match the improvements of new digging equipment.

Nowadays multi-antenna and multi-pass GPR acquisitions demand for new processing techniques that can obtain high quality subsurface images, taking full advantage of 3D data: the development of a fully automated and real-time 3D GPR processing system plays a key-role in overall optical network deployment profitability. Furthermore, currently available computing power suggests the feasibility of processing schemes that incorporate better focusing algorithms.

A novel processing scheme, whose goal is the automated processing and detection of buried targets that can be applied in real-time to 3D GPR array systems, has been developed and fruitfully tested with two different GPR arrays (16 antennas, 900 MHz central frequency, and 34 antennas, 600 MHz central frequency). The proposed processing scheme take advantage of 3D data multiplicity by continuous real time data focusing.

Pre-stack reflection angle gathers $\boldsymbol{G}(\mathbf{x}, \theta; v)$ are computed at n_v different velocities (by the mean of Kirchhoff depth-migration kernels, that can naturally cope with any acquisition pattern and handle irregular sampling issues). It must be noted that the analysis of pre-stack reflection angle gathers plays a key-role in automated detection: targets are identified and the best local propagation velocities are recovered through a correlation estimate computed for all the n_v reflection angle gathers. Indeed, the data redundancy of 3D GPR acquisitions highly improves the proposed automatic detection reliability. The goal of real-time automated processing has been pursued without the need of specific high performance processing hardware (a simple laptop is required). Moreover, the automatization of the entire surveying process allows to obtain high quality and repeatable results without the need of skilled interpreters.

The proposed acquisition procedure has been extensively tested: more than 100 Km of acquired data prove the feasibility of the proposed approach.