Buried pipes monitoring via tomographic imaging in a multifrequency distorted Born approximation framework

Roberta Palmeri, Ilaria Catapano, Francesco Soldovieri, and Lorenzo Crocco
Institute of Electromagnetic Sensing of the Environment, National Research Council of Italy (IREA-CNR), Italy
(palmeri.r@irea.cnr.it)

The continuous monitoring of water services is an important task for the reduction of cost associated with the maintenance of buried utility infrastructure and to prevent environmental and security risks for the territory. To this aim, ICT based solutions seem to be good candidates for the development of innovative and effective technologies for sensing and monitoring. Although several aspects are involved in a complete and accurate monitoring of water services (e.g., planning, optimization and modelling of the distribution system), we focus on the detection of possible failures in terms of pipes and sewers leaks through Ground Penetrating Radar (GPR) [1] and microwave imaging (MWI) techniques [2].

Over the past decades, GPR has become one of the most popular non-invasive subsurface imaging techniques, but the complex nature of the environment in which utility infrastructure detection surveys are carried out makes the interpretation of GPR radargrams difficult to accomplish. Accordingly, the idea is to exploit MWI and, in particular, a frequency domain microwave tomography to obtain accurate images of the investigated scenario by solving an inverse scattering problem (ISP) [2].

The ISP is a non-linear and ill-posed problem, so effective solution strategies and regularization techniques are needed to achieve meaningful solutions. In this respect, we exploit a reconstruction approach based on a linearized model of the electromagnetic scattering, that is the Born approximation (BA), in a multifrequency framework. More in detail, we consider the presence of pipes or sewers in our model and look for possible leaks, thus resulting in a distorted BA inversion approach [3]. A truncated Singular Value Decomposition is finally used for the inversion of the relevant linear operator.

Note that even though being an approximated model, the adoption of a linearized model offers practical advantages in terms of computational burden still achieving useful information on the location/size of anomalies. More in detail, once the data have been collected, few seconds are required for the signal-processing step, thus making this kind of approach very appealing for real-time monitoring. Moreover, ‘false solutions’ affecting non-linear techniques are avoided.

Numerical examples concerning different investigated scenarios and failures will be shown at the Conference.


Acknowledgment: The authors would like to thank the SMART WATERTECH project “Smart Community per lo Sviluppo e l'Applicazione di Tecnologie di Monitoraggio e Sistemi di Controllo Innovativi per il Servizio Idrico Integrato” by which the present work has been financed.