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Optimization of GPR Data Processing for Identification of Tanks and Pipelines in Urban Areas: Case Study at a Fuel Station

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Introduction

This study presents a detailed methodology for processing Ground-Penetrating Radar (GPR) data to identify underground structures in fuel stations, with a focus on detecting buried tanks and pipelines. The research was conducted at a fuel station in Salvador, Brazil, where accurate mapping of subsurface infrastructure is critical for environmental and safety assessments. The study builds on previous work by Jol (2008), which established the suitability of GPR for urban environments, and addresses the challenges of high noise interference and complex target geometries typical of such settings.

Methodology

The survey utilized a GPR system equipped with a 200 MHz antenna, selected for its optimal balance between resolution and penetration depth in urban environments, as recommended by Lai, Dérobert, and Annan (2018). Data acquisition involved 23 radargrams, each 10 meters long, spaced 0.5 meters apart, with a trace interval of 0.1 meters. This configuration ensured comprehensive coverage for detecting targets of typical dimensions in civil infrastructure. Data processing was performed using the open-source software GPRPy (Plattner, 2020), which allows for customized filtering and visualization routines. The processing sequence included: (i) Contrast enhancement (factor 3) to improve dynamic range and highlight reflectivity variations; (ii) Trace mean removal to eliminate persistent noise components; (iii) Time-varying gain correction (power-law exponent 0.3) to compensate for signal attenuation with depth, following Goodman and Piro (2013); (iv) oving-average smoothing (5-sample window) to reduce high-frequency noise while preserving spatial resolution; (v) Dewow filtering (100-sample window) to remove low-frequency noise associated with system artifacts, as emphasized by Wilson et al. (2009). The final data visualization employed an inverted grayscale scheme, which enhanced the contrast of subsurface anomalies for interpretation.

Results and Conclusions

The processed radargrams clearly identified the signatures of buried metallic structures, characterized by hyperbolic reflections. Additionally, zones of signal attenuation were interpreted as potential indicators of leaks or structural degradation in tanks. Key findings include: (a) The methodology effectively resolved subsurface targets despite the high noise levels typical of urban environments; (b)The combination of contrast enhancement, gain correction, and dewow filtering significantly improved data quality; (c)The 200 MHz antenna provided sufficient resolution to detect tanks and pipelines while achieving the necessary penetration depth; (d) The study underscores the importance of tailored acquisition parameters and adaptive processing techniques for GPR surveys in complex urban settings: (e) The proposed approach offers a reliable tool for environmental and structural assessments in fuel stations, with potential applications in regulatory compliance and infrastructure maintenance.