A GPR investigation of railway ballast for signal noise filtering of railway sleepers effects

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Ground-penetrating radar (GPR) has proven to be a very effective tool for the assessment and health monitoring of linear transport networks. To date, the use of this technology is well-established in highway engineering for the inspection of roads at the network level. This is mostly due to the high reliability of the available data processing algorithms and the relatively ease of interpretation of the GPR image outputs.
Conversely, the use of GPR for railway inspections has been not widespread likewise. Among the possible causes for this gap, it is worthy of mention the high rate of disturbance created by sleepers and rails to the GPR signal. Indeed, reflections from these pieces of structural components – and particularly from their metallic parts – may reduce or totally affect the interpretation of the subsurface features.
This paper evaluates the influence of concrete railway sleepers on the GPR signal collected to assess railway ballast conditions in a laboratory environment. More specifically, the main aim is to comprehend the disturbance given by these components for clean and fouled ballast.
To this purpose, numerous GPR tests were carried out and a dedicated set-up was created. A methacrylate tank with dimensions of 1.5 m × 1.5 m × 0.50 m was filled up with limestone railway ballast aggregates, in both clean and polluted conditions. Hence, two concrete sleepers of standard dimensions were laid above the material. GPR tests were performed using 4 different air-launched antenna systems with frequencies of 1000 MHz, 1500 MHz and 2000 MHz (in both the standard and low-powered version). Each antenna system was oriented in two different ways, i.e. longitudinally and transversely with respect to the tracks orientation. A dedicated data processing scheme was used to filter out noise and unnecessary information from the signal.
Investigations were made by way of comparison between the configuration with ballast material only and the configuration with ballast material and sleepers (in both clean and fouled conditions). Results demonstrated the viability of the proposed data processing scheme to single out the disturbance of sleepers to the GPR signal and a method to minimise the noise was also proposed.

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