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Testing of APEX algorithm on TU1208 radargrams from the IFSTTAR geophysical test site

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In this contribution we analyse the performance of APEX algorithm on experimental Ground Penetrating Radar (GPR) profiles recorded at the IFSTTAR (French Institute of Science and Technology for Transport, Development and Networks) geophysical test site in Nantes, France. The algorithm was developed in Serbia, in the framework of the COST Action TU1208 "Civil engineering applications of Ground Penetrating Radar," and the dataset is part of the TU1208 Open Database of Radargrams.

APEX stands for 'Algorithm for Point Extraction.' The algorithm is primarily developed to detect and analyse hyperbolic reflections in radargrams, generated as a result of GPR scanning of a subsoil/structure hosting circular-section cylindrical objects. The algorithm considers a radargram as raster data, with each column corresponding to an individual scan, whilst each row corresponds to a possible reflection of electromagnetic waves, occurring at a certain depth. The goal of the algorithm is to detect the presence of hyperbolas, and then determine the coordinates of their apices as well as of the points on hyperbola prongs. For coarse search and fast localization of hyperbolic reflections in a radargram, an artificial neural network (ANN) is used. The ANN is trained using a set of positive and negative samples, where positive samples are hyperbolic reflections and negative samples are other signatures typically present in a radargram (reflections by soil layers, scattering by non-cylindrical objects, and more). In the next step, a starting pixel is chosen in a selected Segment of Interest (SOI), containing a hyperbolic reflection; the further procedure is based on the analysis of the surrounding pixel intensities, until the coordinates of the hyperbola apex are determined. In the final phase, the points on the prongs are detected. APEX is implemented in MATLAB.

The IFSTTAR geophysical test site area is 30 m x 5 m wide. The test site consists of vertical sections filled with different materials and hosting different objects, such as pipes, cables or walls. The filling materials and objects were selected to correspond to common scenarios in urban areas. The test site was designed in such way that it can be used for test, comparisons and verification of different geophysical methods and devices, including GPR. The radargrams selected for APEX testing contain hyperbolic reflections generated by an empty steel pipe with a 8-cm diameter, a PVC pipe filled with water and having a 10-cm diameter, and an empty PVC pipe with a 10-cm diameter. Data acquisition was done by using GPR antennas with central frequencies of 200 MHz, 400 MHz and 900 MHz.