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Volunteering for the future – Geospatial excellence for a better living

Analysis of the possibility of classification the types of utilities networks on the GPR images

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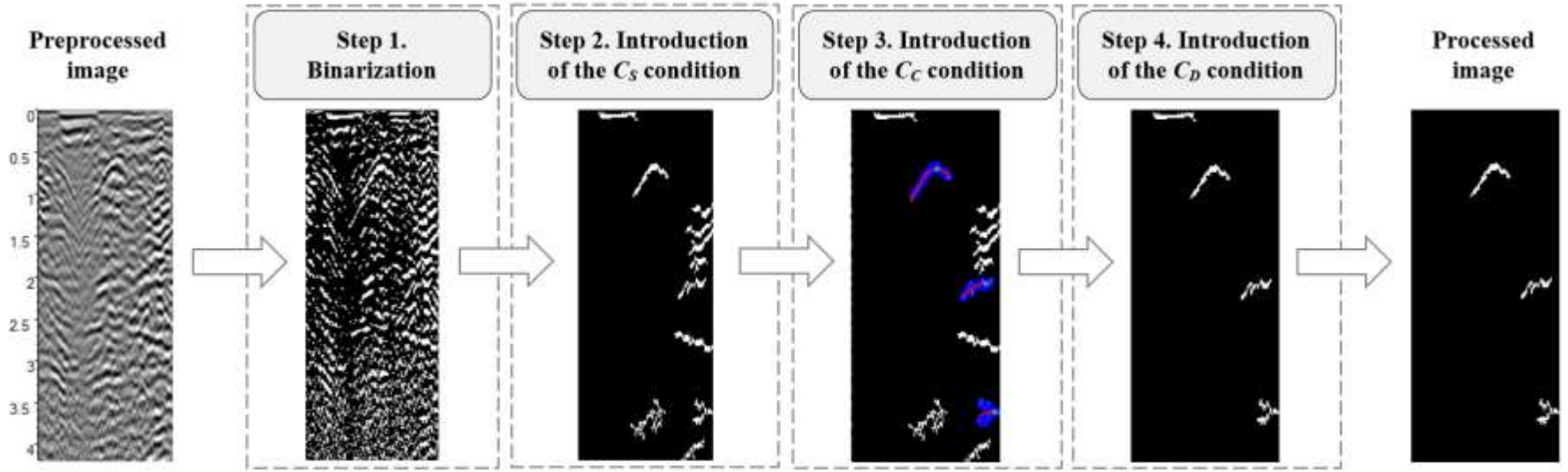
Proposed method for the detection of true hyperbolas

The proposed method of hyperbola detection is based on converting the RGB image to grayscale, background removal, edge detection, fitting the object into the set of detected pixels, and selecting only those hyperbolas that meet the predefined conditions:

- size of the object – (C_S),
- curvature of the object – (C_C),
- depth of the object – (C_D).

The study used a total of 105 images of hyperbolas showing various types of underground utilities networks i.e., power, water, sewage, heating, telecommunications and gas networks.

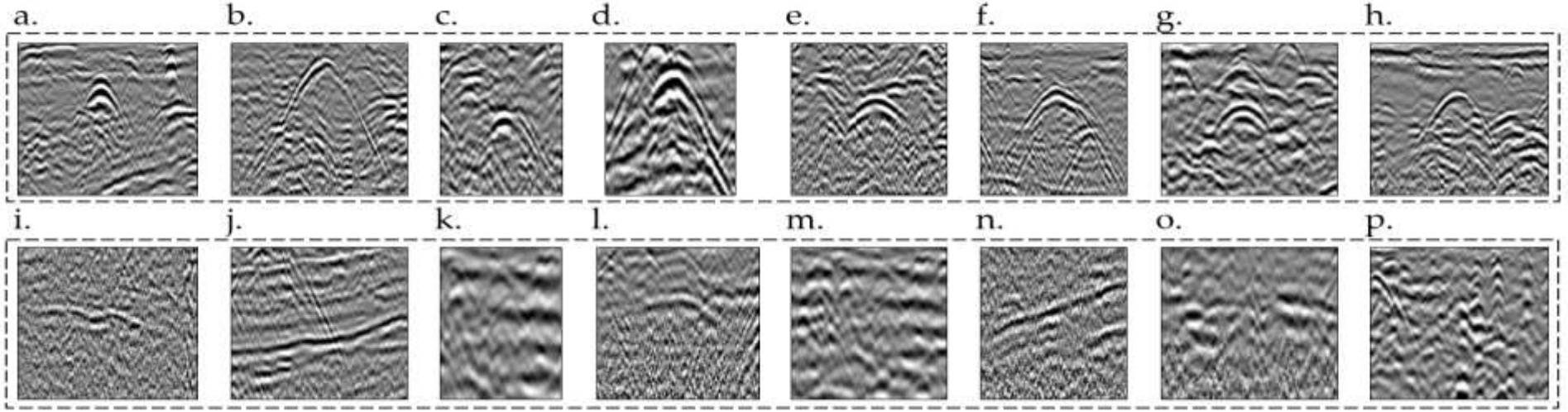


Scheme of the proposed algorithm for the detection of true hyperbolas.

Problems of classification of utility networks types

- detection efficiency - detection of objects which are not utility networks
- completeness of hyperbolas
- classifying false objects

detection with the efficiency from about 79% to about 99%



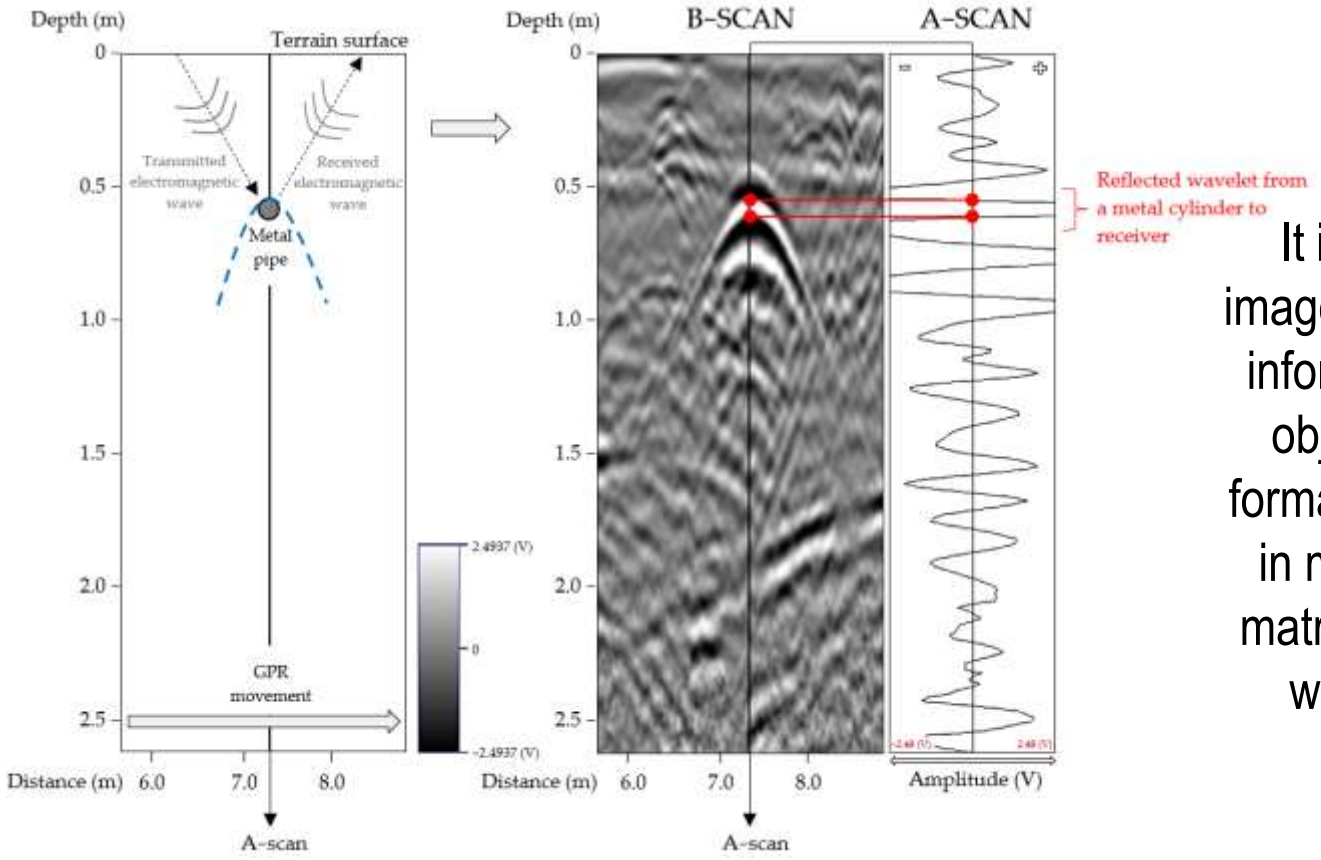
TRUE HYPERBOLAS

FALSE HYPERBOLAS

Location of the underground facility on the A-scan and B-scan

A–SCAN

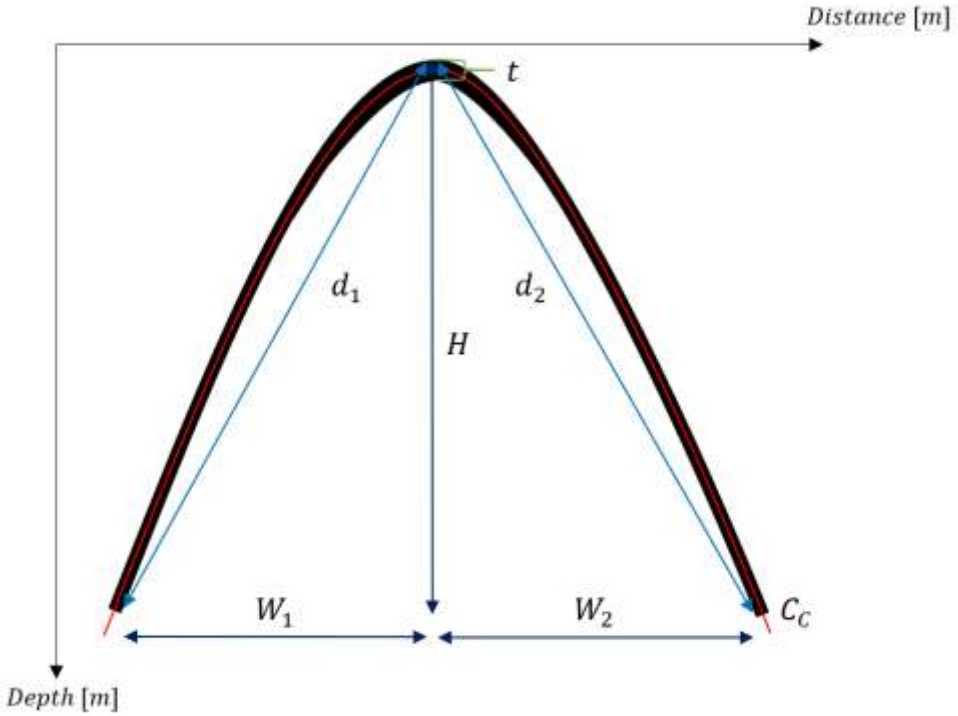
It is a set of reflected waves (recorded in the domain of time), captured along a vertical straight line crossing the ground at the given point.



B–SCAN

It is a set of multiple A-scan images that represent the current information about underground objects. The process of their formation consist, among others, in mapping processed A-scan matrices to images in grayscale with 256 brightness levels.

Methodology of the classification possibilities

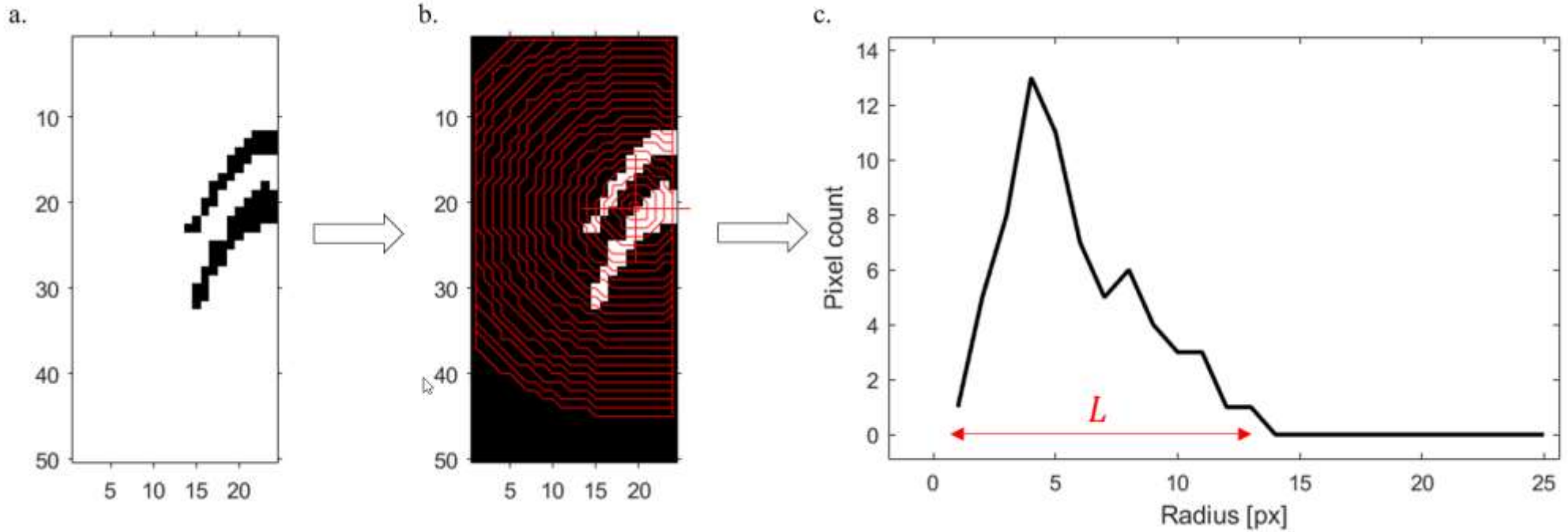


Definition of hyperbola characteristic parameters.

Geometric features of a hyperbola:

- curvature (C_C),
- size (C_S),
- completeness of the hyperbola (C),
- symmetry of the hyperbola (S),
- width (W) and height (H),
- depth (C_D),
- thickness of the hyperbola – counted at its vertex (t),
- the signal length – (L).

Using Ring-Projection Algorithm to reduction of image dimension to signal



Scheme of reduction of image dimension to signal: (a) binary image of hyperbola, (b) the centroid of the mass distribution on the x-y plane with the rings of given radius, (c) the ring-projection of the image of hyperbola.

Various types of underground networks

ELECTRICITY NETWORK

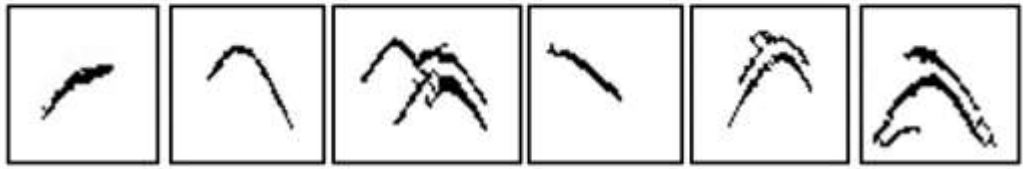
TELECOMMUNICATIONS NETWORK

WATER NETWORK

SEWAGE NETWORK

HEATING NETWORK

GAS NETWORK



Test hyperboles representing different network types

Completeness of extracted hyperbolas

GROUP I
COMPLETE OBJECTS

objects with a vertex and two arms of a hyperbola

GROUP II
NEARLY COMPLETE OBJECTS

objects with a vertex and the left or right arm of the hyperbola

GROUP III
INCOMPLETE OBJECTS

objects with only one arm or the apex of the hyperbola

Proposed Method of Automated Classification of True Hyperbolas

$w_{C_S}, w_{C_S}, w_{C_D}$ - weight coefficients

$$Q = \underset{0.24}{w_{C_S}} \cdot C_S + \underset{0.52}{w_{C_C}} \cdot C_C + \underset{0.24}{w_{C_D}} \cdot C_D$$

condition for the curvature of the object

condition for the size of the object

condition for the depth of the object

For the results obtained with proposed algorithm the following ranges (Q) are proposed for the classification of objects detected in the radargram:

- For $Q \leq 20{,}0 \rightarrow$ certain point (*G1'*),
- For $Q \in (20.0; 23.0 > \rightarrow$ uncertain point (*G2'*),
- For $Q > 23{,}0 \rightarrow$ least certain point (*G3'*)

The classification of hyperbolas efficiency results, with respect to the reference data from NGCR:

- About 58%
- About 39%
- About 48%

Conclusions

1. The proposed algorithm of automatic detection of true hyperbolas allows for their detection with the efficiency from about 79% to about 99%.
2. The effectiveness of the hyperbolic classification was, respectively: about 58% (for certain objects), about 39% (for uncertain objects) and about 48% (for least certain objects).
3. The article presents the methodology for possibilities of classification of the types of underground utilities based on the geometric features of a hyperbolas.
4. The paper provides an overview about reducing the dimension of two-dimensional image into one-dimensional signal, which allowed to characterize the hyperbola by the length of the signal.
5. The results obtained showed significant differences between the parameters characterizing the shape and size of individual hyperbolas.

Thank you for your attention

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