APPLICATION OF AN ADVANCED ALGORITHM FOR AUTOMATED HYPERBOLA DETECTION, INCLUDING CANNY EDGE DETECTOR, TO GPR DATA FROM IFSTTAR TEST FIELD

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Reasons & Related work

- Automated processing and extraction of useful information from GPR data is a complicated task, for which various approaches have been developed during the last years.

- Approaches: Signal processing or image processing

- Image processing – time demanding, noise sensitivitty
  - Full, dense radargrams or tresholded, sparse radargrams
  - Simplification – extraction of the data from the hyperbolic reflection (e.g. binarization)

Canny

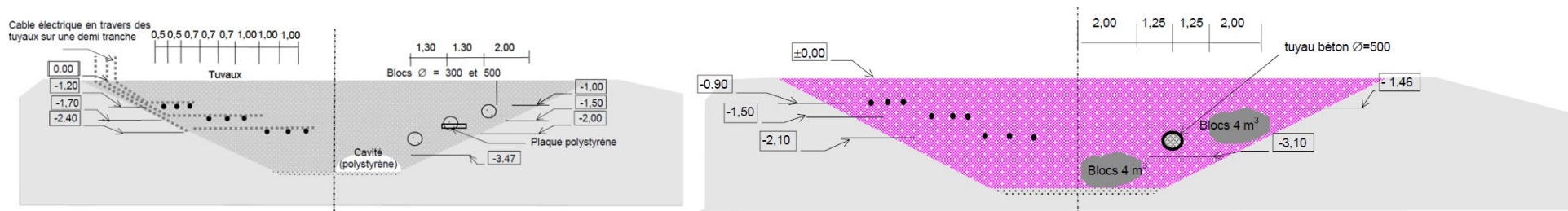- **Canny edge detector**
  - Good detection and localization of edge pixels, and unique filter response
  - It is considered as the ideal edge detection algorithm for images that are corrupted with noise
  - It has a wide range of application in current algorithms for image processing

- **Main purposes**
  - Identify radargram portions wherein hyperbolic reflections apices are present and extract the coordinates of such apices.
    - Hyperbolic reflections are generated as a result of scanning objects of a circular cross-section
  - Examine if this type of radargram processing can be applied in real/near-real time?
  - Find a condition that will quickly and efficiently remove a large number of edge pixels that do not feature hyperbolic reflection
  - Take into account robustness and processing speed

IFSTTAR

- IFSTTAR (The French Institute of Science and Technology for Transport, Development, and Networks) test field in Nantes, France.

- Test field consists of vertical sections filled with different materials and hosting many buried objects, such as cables and pipes, or walls and stones, imitating common scenarios in urban areas.

- Radargrams containing hyperbolic reflections of 200 and 400MHz antenna center frequencies were analyzed.

Methodology

- Canny edge detector is applied on entire radargram

- Over 92% reduction in the number of edge pixels on the radargram

- Further radar processing is based on the analysis of edge pixels

200MHzGn14-20-2.dzt
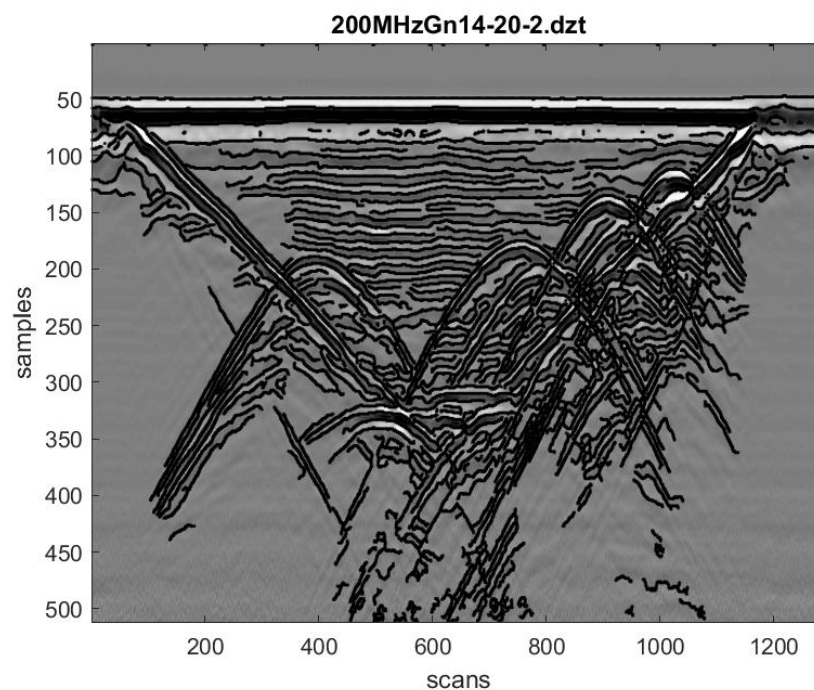
The first stage of algorithm

- Eliminate a large number of edge points that do not feature the subject of hyperbolic reflection
  - This is important because in the first step, the largest number of edge pixels is expected

- **Simple condition**
  - It is necessary that edge pixels on both sides have at least one edge pixel in the immediate vicinity

a) - The first neighboring pixel is checked on both sides of the observed edge pixel

b) - The second neighboring pixel is checked on both sides of the observed edge pixel

c) - The third neighboring pixel is checked on both sides of the observed edge pixel

Results

Edge pixels [Reduction 92.75%]

Before: **660992**   After: **47944**
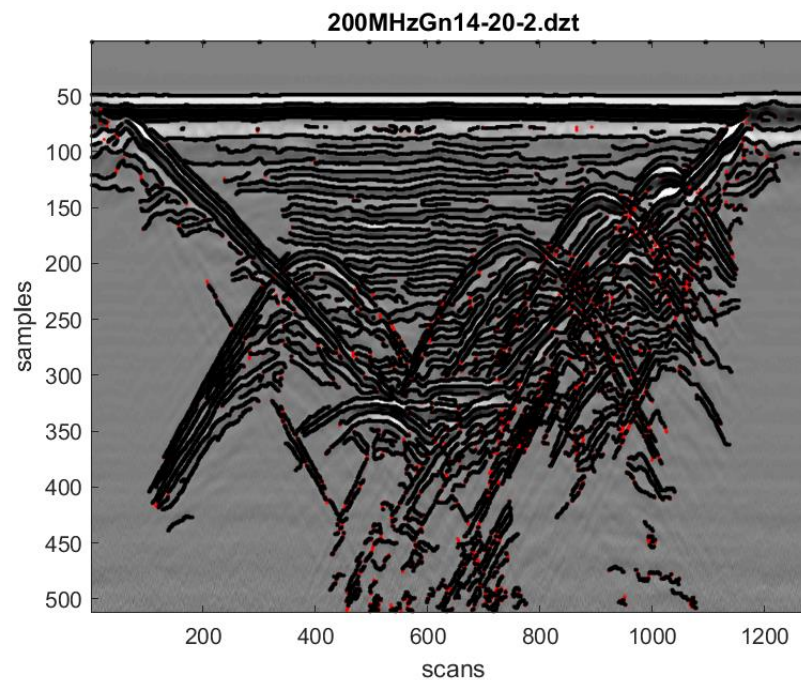
Red – eliminated

Black – remaining edge pixels
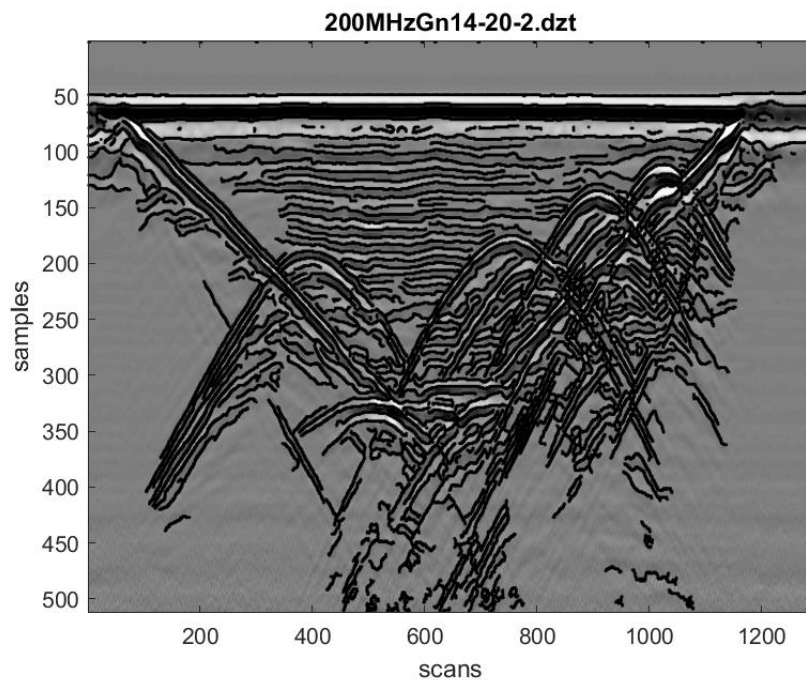
Condition a)

Reduction of edge pixels: 6.03 [%]

Processing time: 0.091 [s]
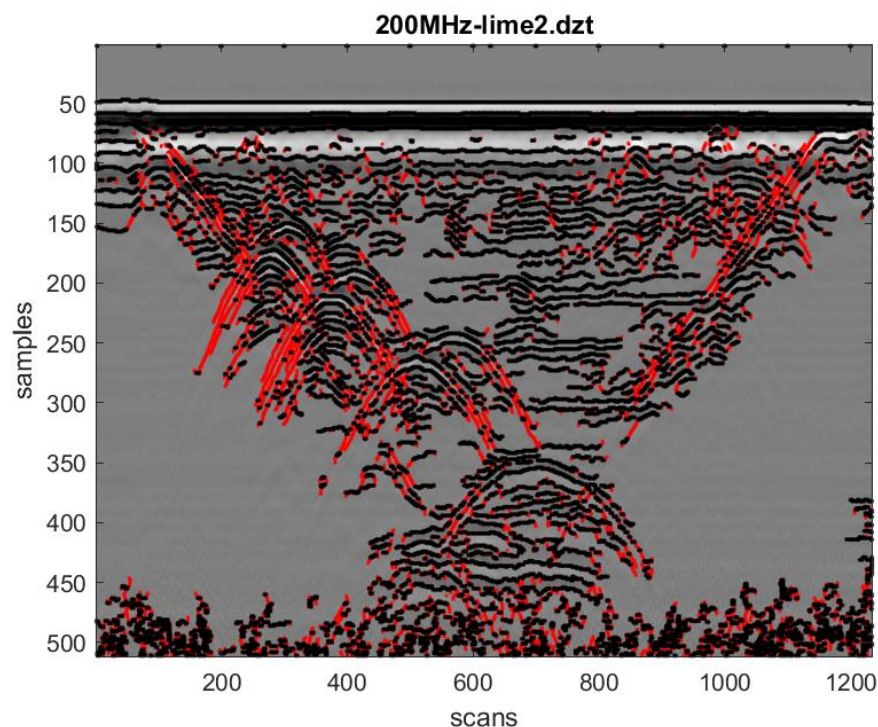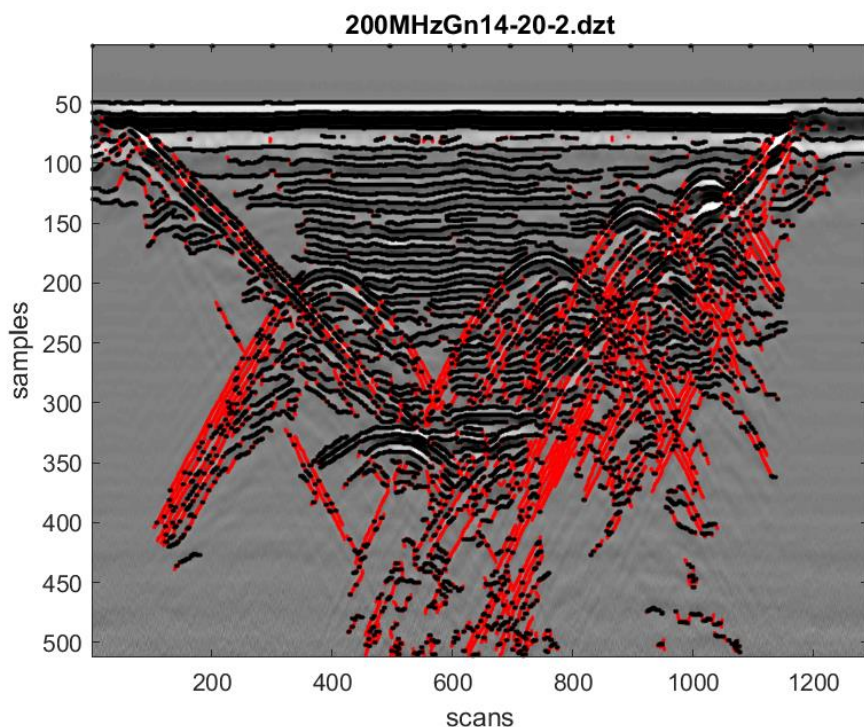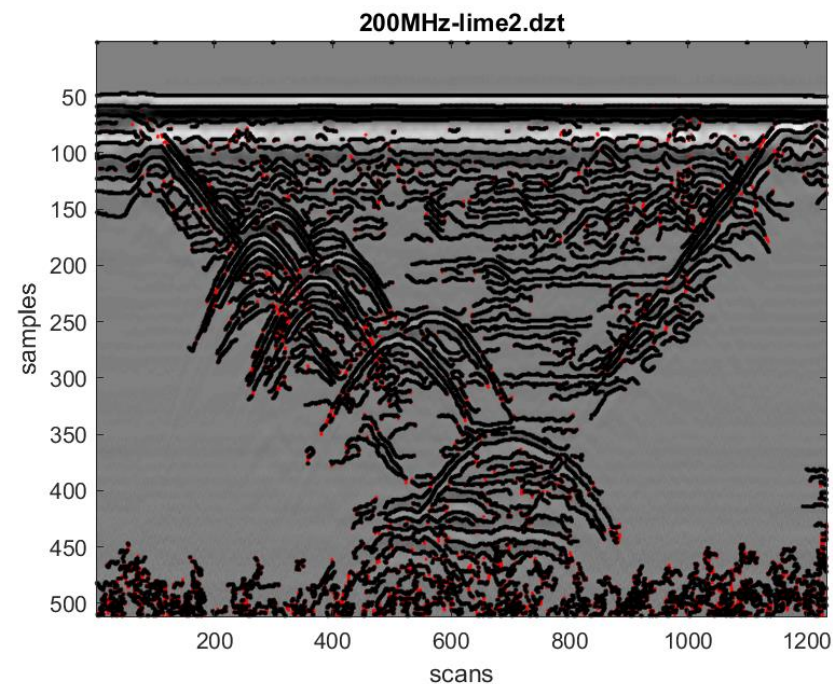

200MHzGn14-20-2.dzt

200MHzGn14-20-2.dzt

Results

Condition b)

- Reduction of edge pixels: **39.97** [%]
- Processing time: **0.004** [s]

Condition c)

Reduction of edge pixels: **39.02** [%]

Processing time: : **0.077** [s]

Results

Edge pixels [Reduction 92.68%]
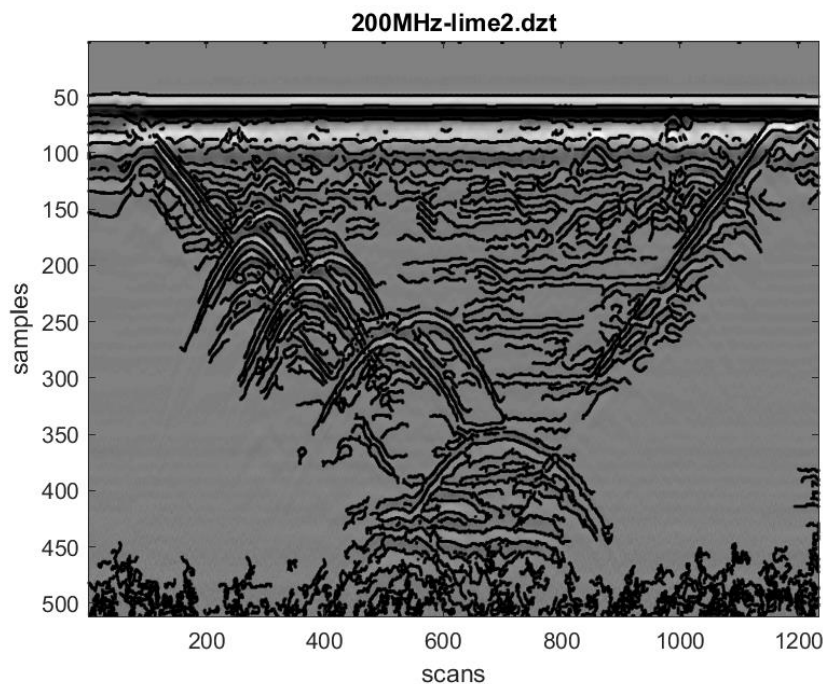
Before: **632320**   After: **46302**

Red – eliminated

Black – remaining edge pixels

Condition a)
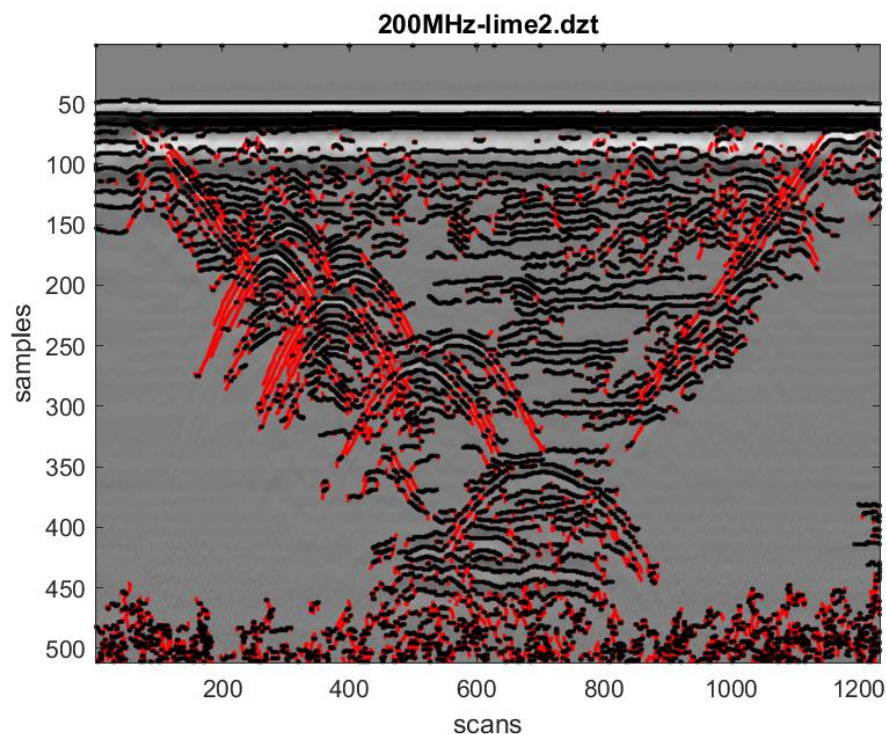
Reduction of edge pixels: **10.09** [%]
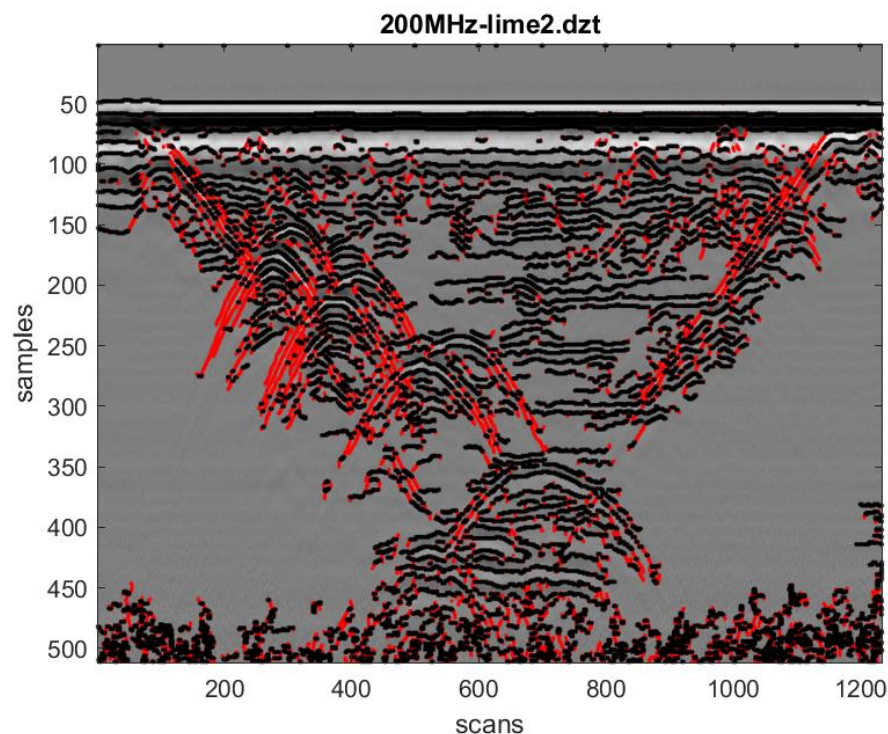
Processing time: **0.186** [s]

Results

Condition b)

- Reduction of edge pixels: **40.51** [%]
- Processing time: **0.012** [s]

Condition c)

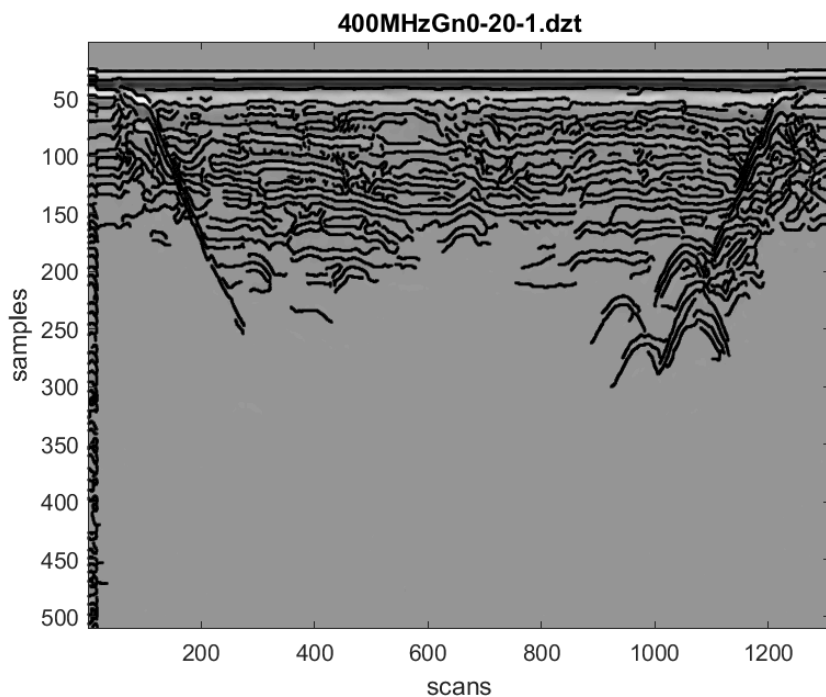Reduction of edge pixels: **36.62** [%]

Processing time: : **0.084** [s]

200MHz-lime2.dzt

200MHz-lime2.dzt

Results

Edge pixels [Reduction 95.41%]

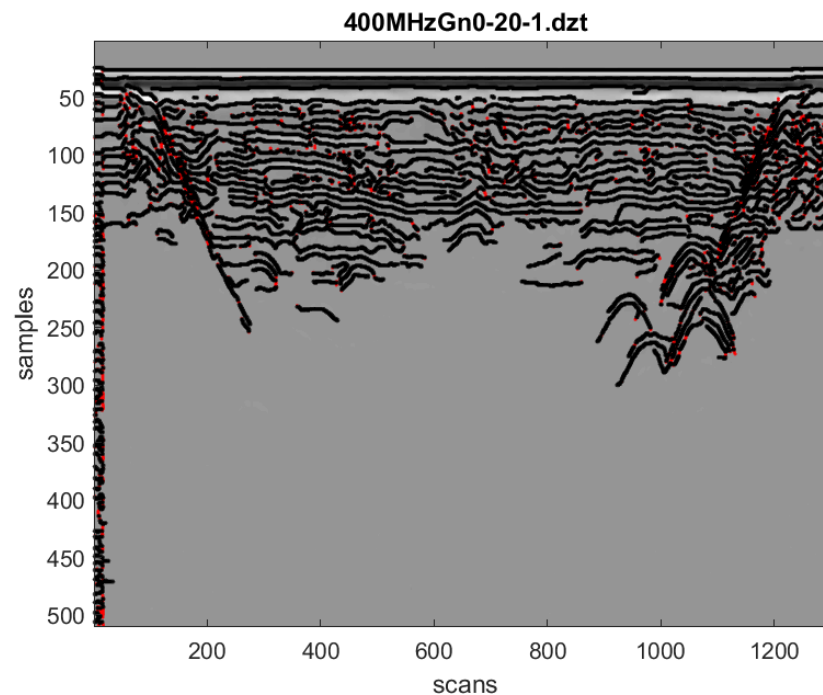Before: **668100**   After: **30667**

Red – eliminated

Black – remaining edge pixels
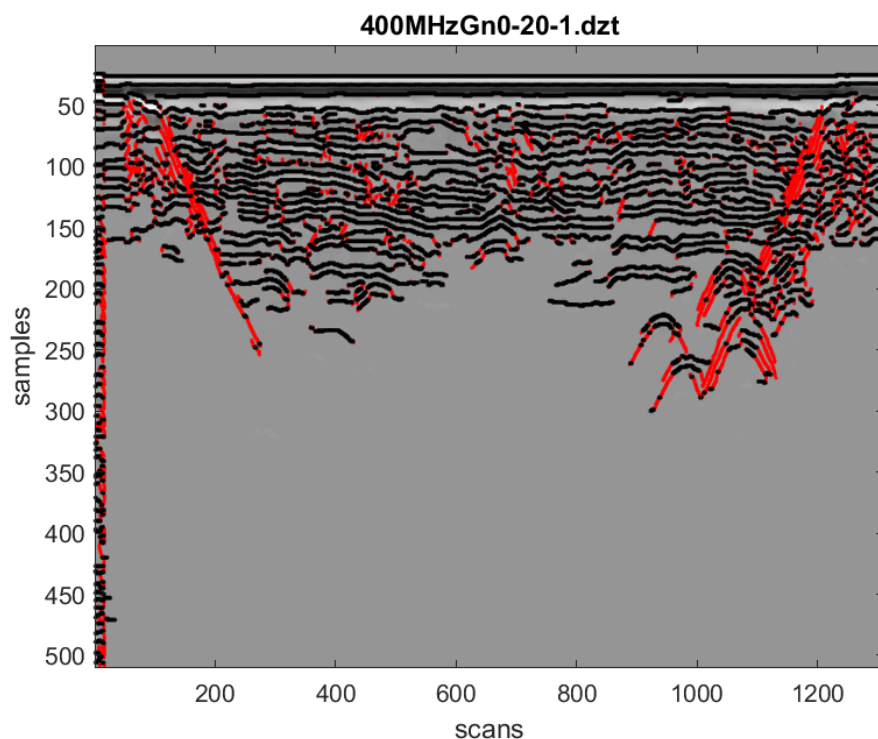
Condition a)

Reduction of edge pixels: 5.61 [%]
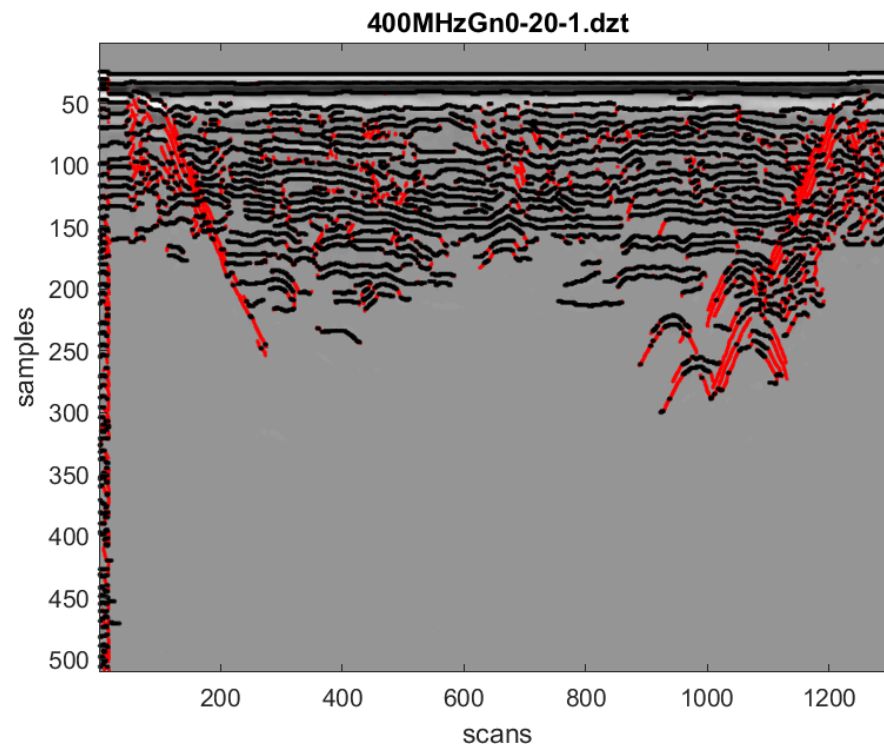
Processing time: 0.115 [s]

Results

Condition b)

- Reduction of edge pixels: **25.16** [%]
- Processing time: **0.005** [s]

Condition c)

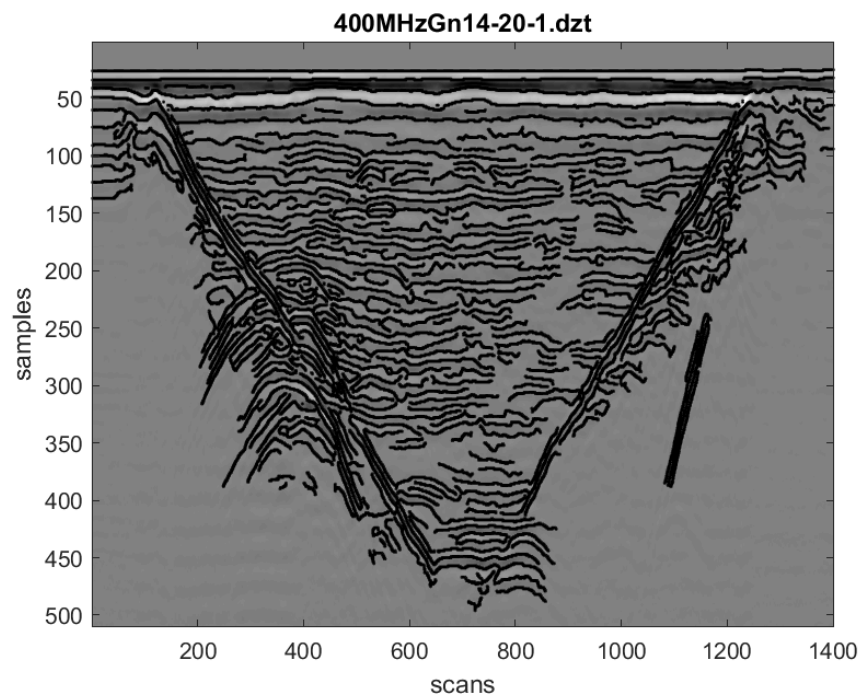Reduction of edge pixels: **24.23** [%]

Processing time: : **0.061** [s]

Results

Edge pixels [Reduction 93.60%]
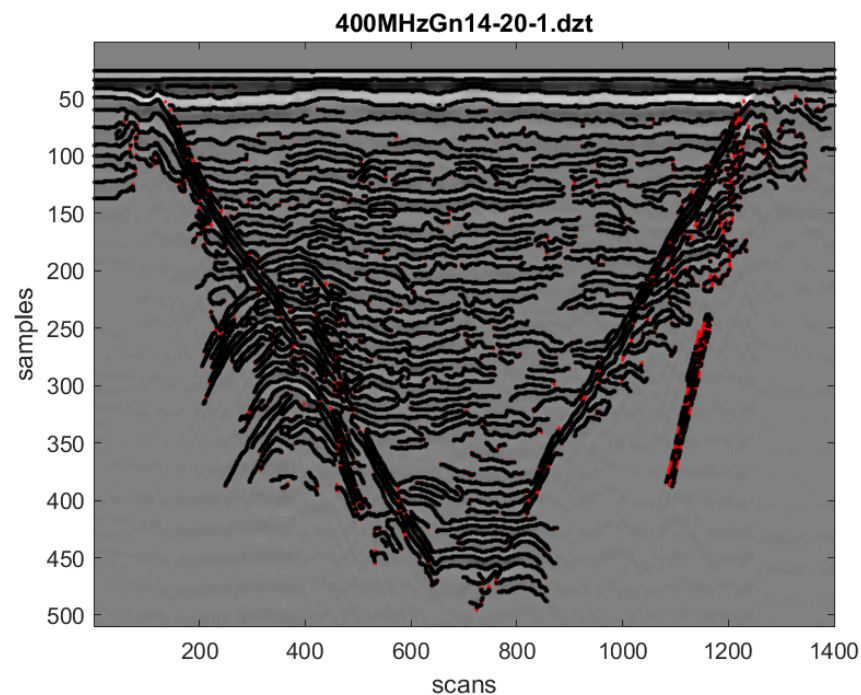
Before: **714510**   After: **45741**

Red – eliminated

Black – remaining edge pixels

Condition a)

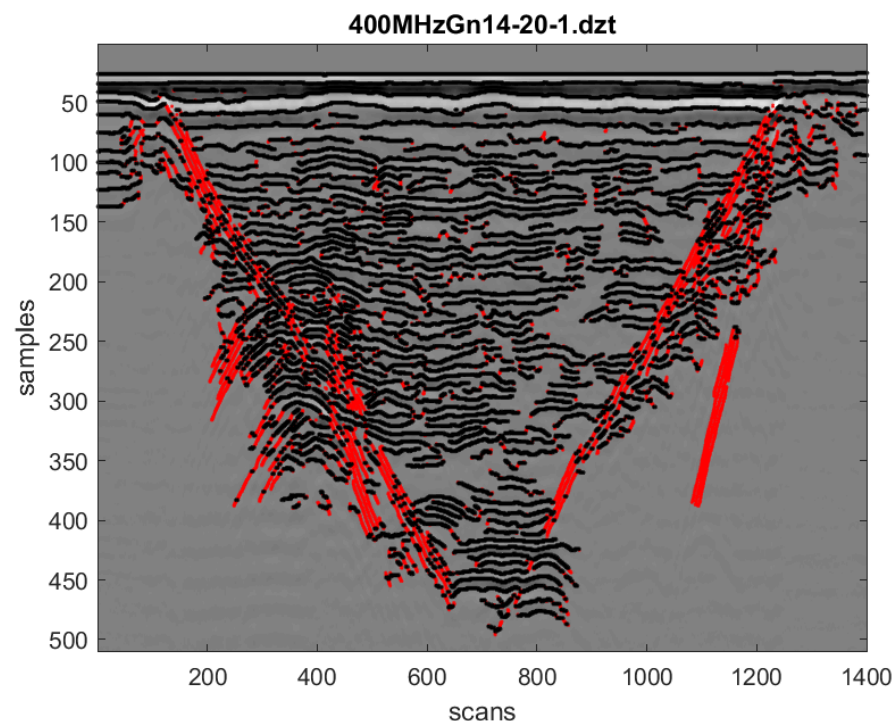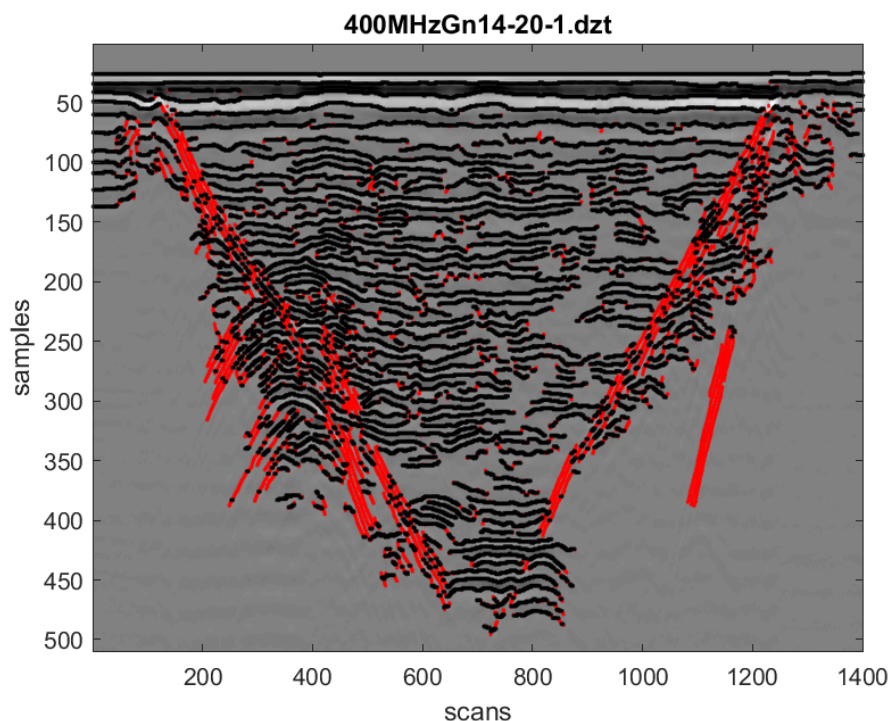Reduction of edge pixels: **4.12** [%]

Processing time: **0.055** [s]

Results

Condition b)

- Reduction of edge pixels: **25.34** [%]
- Processing time: **0.004** [s]
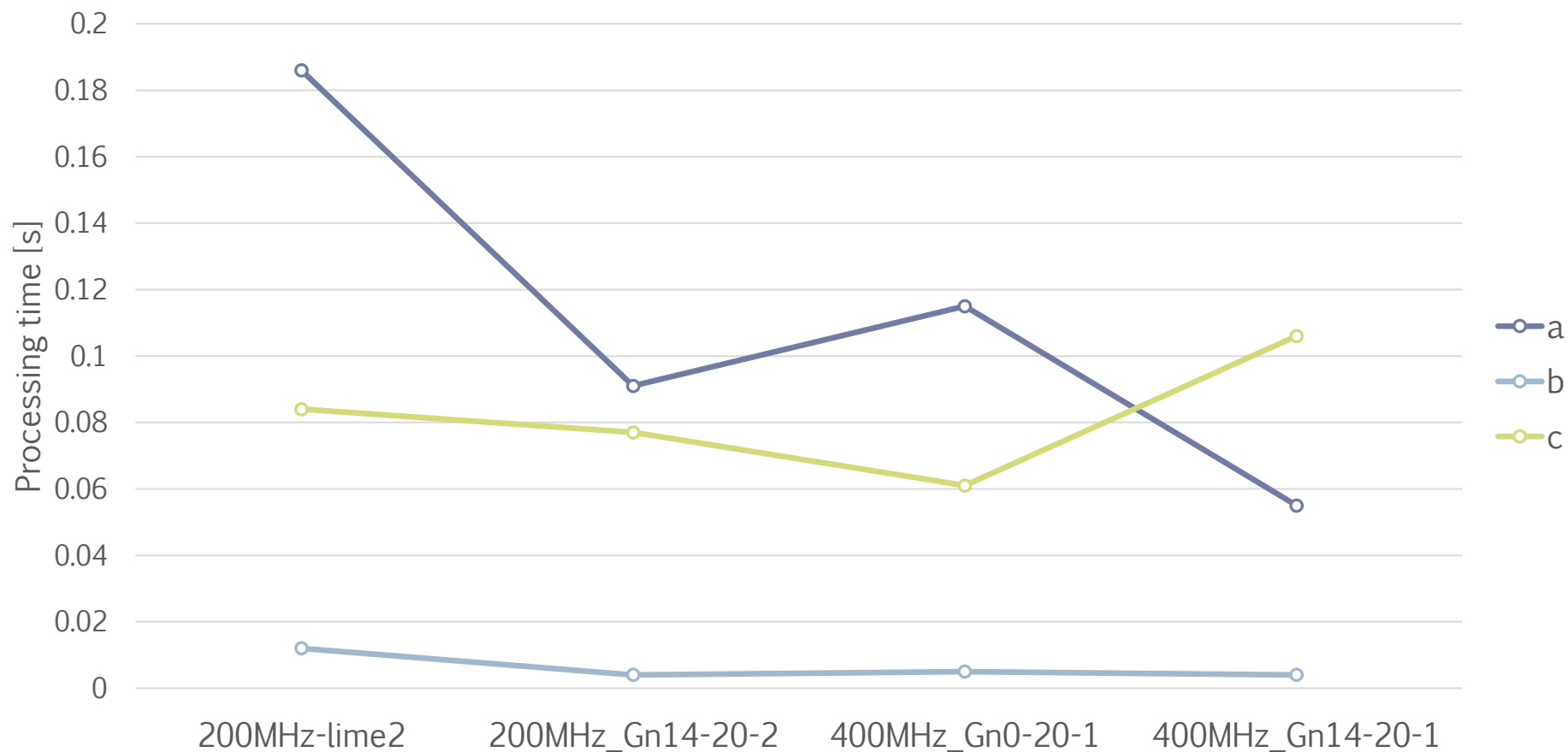
Condition c)

Reduction of edge pixels: **24.91** [%]

Processing time: : **0.106** [s]

400MHzGn14-20-1.dzt

400MHzGn14-20-1.dzt

Analysis of processing time

Processing time by conditions

Conclusion

- Extraxtion of edge pixels in radargram, largely decreases the number of input pixels for further processing.

- Canny detector can be used in the initial stages of the algorithm working in near real-time.

- High precentage of edge pixels that represent noise can be eliminated Nusing simple criterion.

- Criterion a) resutled yielded the lowest percentage of eliminated pixels, while criteria b) and d) have a similar result (25 – 40 % of eliminated pixels).

- Less input data leads to more efficient processing in further steps of the algorithm.

- Pixels in the vicinity of the hyperbola apices are retained, which is important for following steps of the algorithm.

Directions for future development

- Examine additional conditions for elimination of edge pixels and adopt an optimal solution.

- Develop the next steps of an algorithm that will use edge points obtained in the first step of the algorithm as input data.

- Examine and define criteria that will retain points that characterize the apices of hyperbolic reflections.

Thank you for your attention!