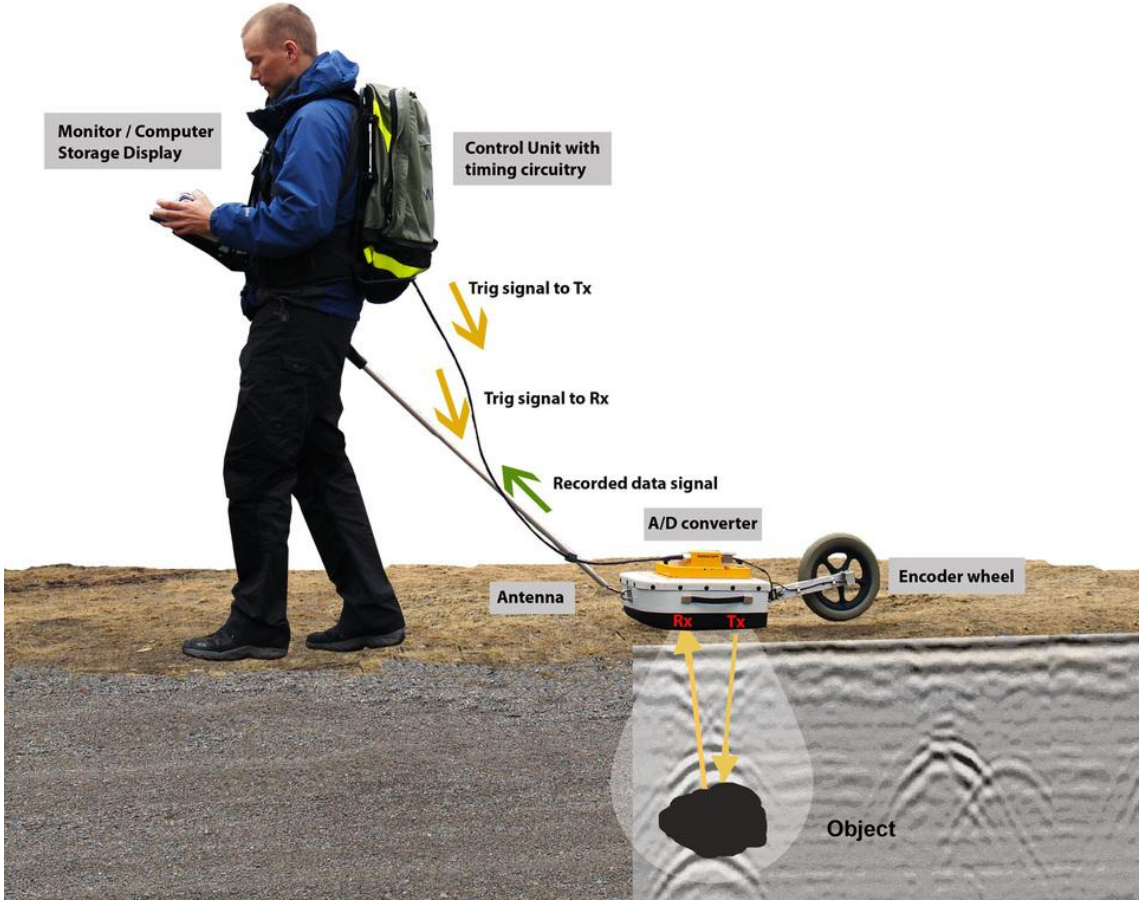
FOCUSING GROUND PENETRATING RADAR IMAGES WITH VERTICAL OFFSET FILTERING

A. Benter, W. Moore, and
M. Antolovich

Abstract

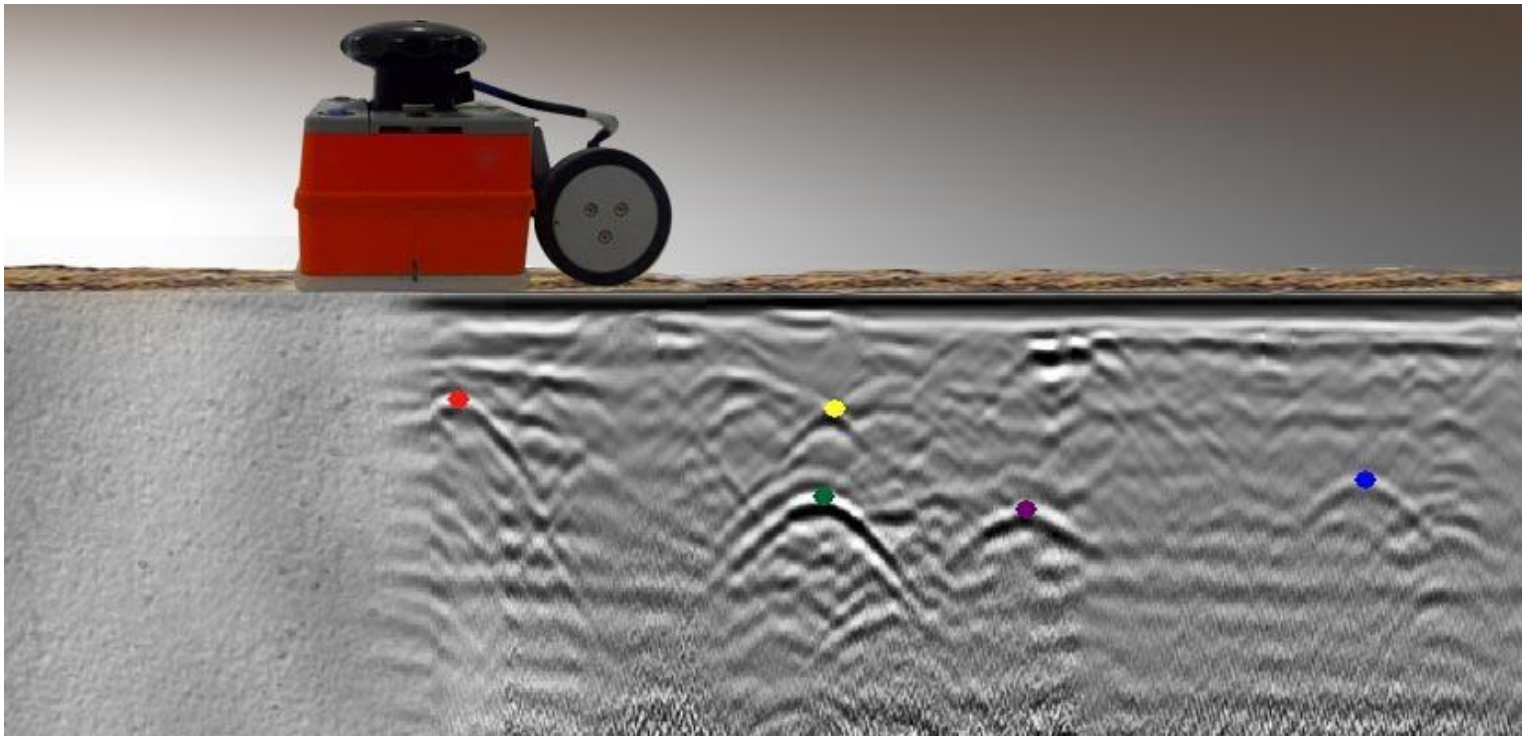
Existing focusing techniques for Ground Penetrating Radar (GPR) rely on migration of 2D or 3D images to remove clutter originating from objects laterally offset from the antenna. In applications requiring real-time focusing, a method operating on 1D trace data is required. This paper presents a new algorithm for focusing GPR images, the Vertical Offset Filter (VOF), using simulated and real GPR data.

GPR provides a mechanism to detect reflected signals from subsurface objects and changes in the electromagnetic characteristics of the ground material.



This paper presents a novel method to focus GPR signals.

As the antenna is moved across the surface, the range to the illuminated object also changes - firstly decreasing as the antenna approaches until the shortest range is recorded when the antenna is directly above the object, then increasing as the antenna moves past and beyond the object. This change is depicted in B-scans as a hyperbola.



Typical hyperbolic pattern of a point reflector in motion across a B-scan is given by equation:

$$z_i = \sqrt{(x_i - x_0)^2 + z_0^2}$$

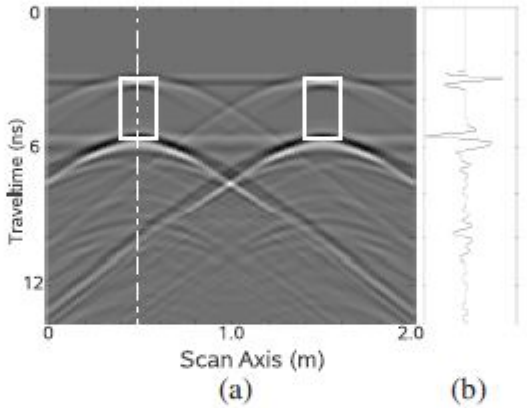


Figure 1. Synthetic scan of two objects ($\epsilon_r = 3.5$) located in free space ($v = 0.29979\,\mathrm{m/ns}$). (a) B-Scan, (b) A-scan.

The VOF improves the maximum convexity migration method by working only on individual A-scans, rather than the entire B-scan data. This reduces the computational cost to a 1-D processing method, while also allowing construction of B-scans or C-scans.

```
foreach A-Scan x_i do
    foreach Offset A-Scan x_{i,k} do
        forall Sample Values z_{i,k} do
            if z_{i,k} is a signal peak then
                s_{i,k} = 1;
            else
                s_{i,k} = 0;
            end
        end
    end
    Align k scans by vertical offset h;
    z_i = sum_{k=1}^{m} s_{i,k};
    if z_i == m then
        z_i = 1 //keep common signal peak;
    else
        z_i = 0 //discard signal peak;
    end
end
```

Algorithm 1: The Vertical Offset Filter (VOF) algorithm.

To demonstrate the algorithm, a GPR scan was synthesized using MatGPR. Synthetic scans were produced using a finite-difference time domain (FDTD) 2D method simulating a 1200MHz antenna.

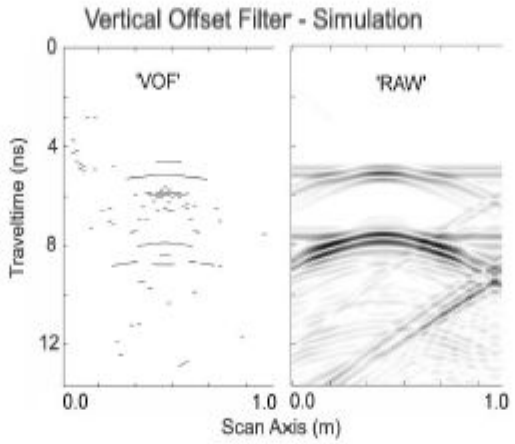


Figure 3. Raw synthetic data (RAW) and after the Vertical Offset Filter applied (VOF).

The first set of experiments.

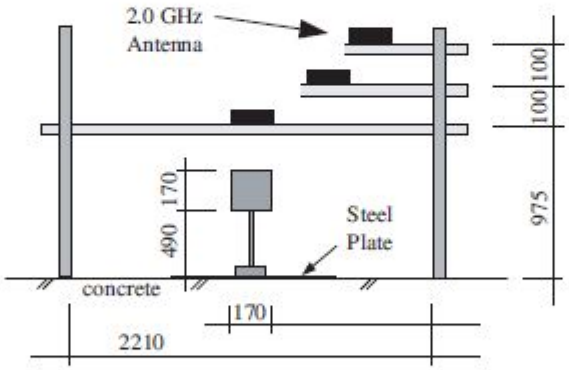
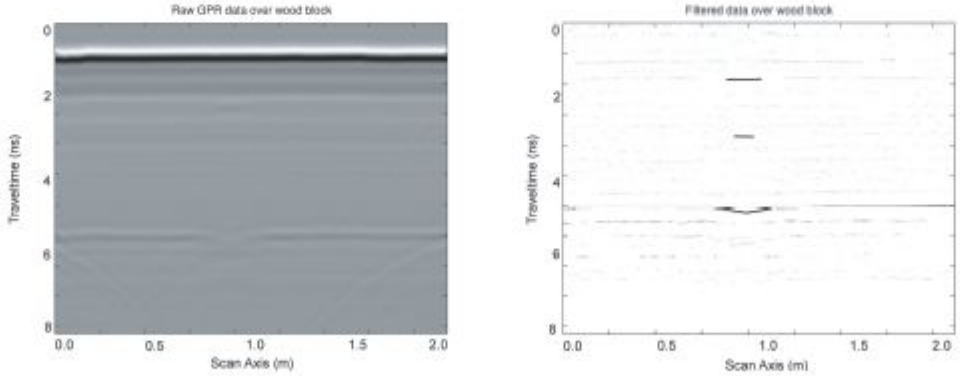


Figure 4. Experimental setup to capture VOF data over a wood block similar to the simulated scans.

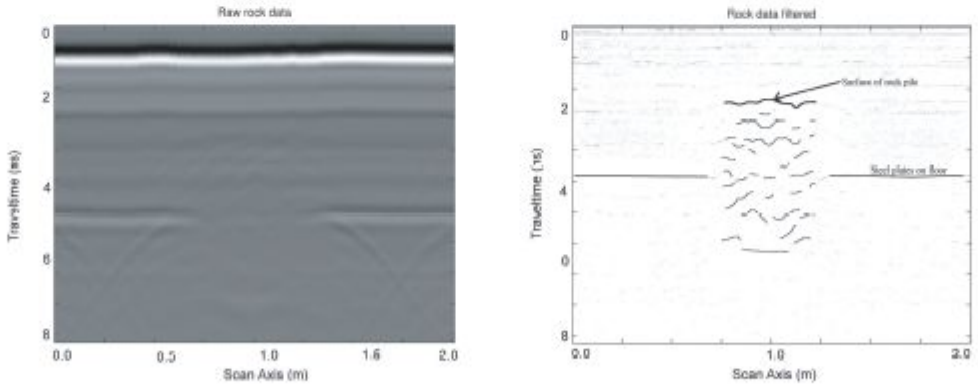


(a) Raw data (b) VOF filtered data

Figure 5. Real GPR scans over wood block.

Further experiments.

Figure 6. Experimental setup to capture VOF data over rock samples.



(a) Raw data (b) VOF ltered data

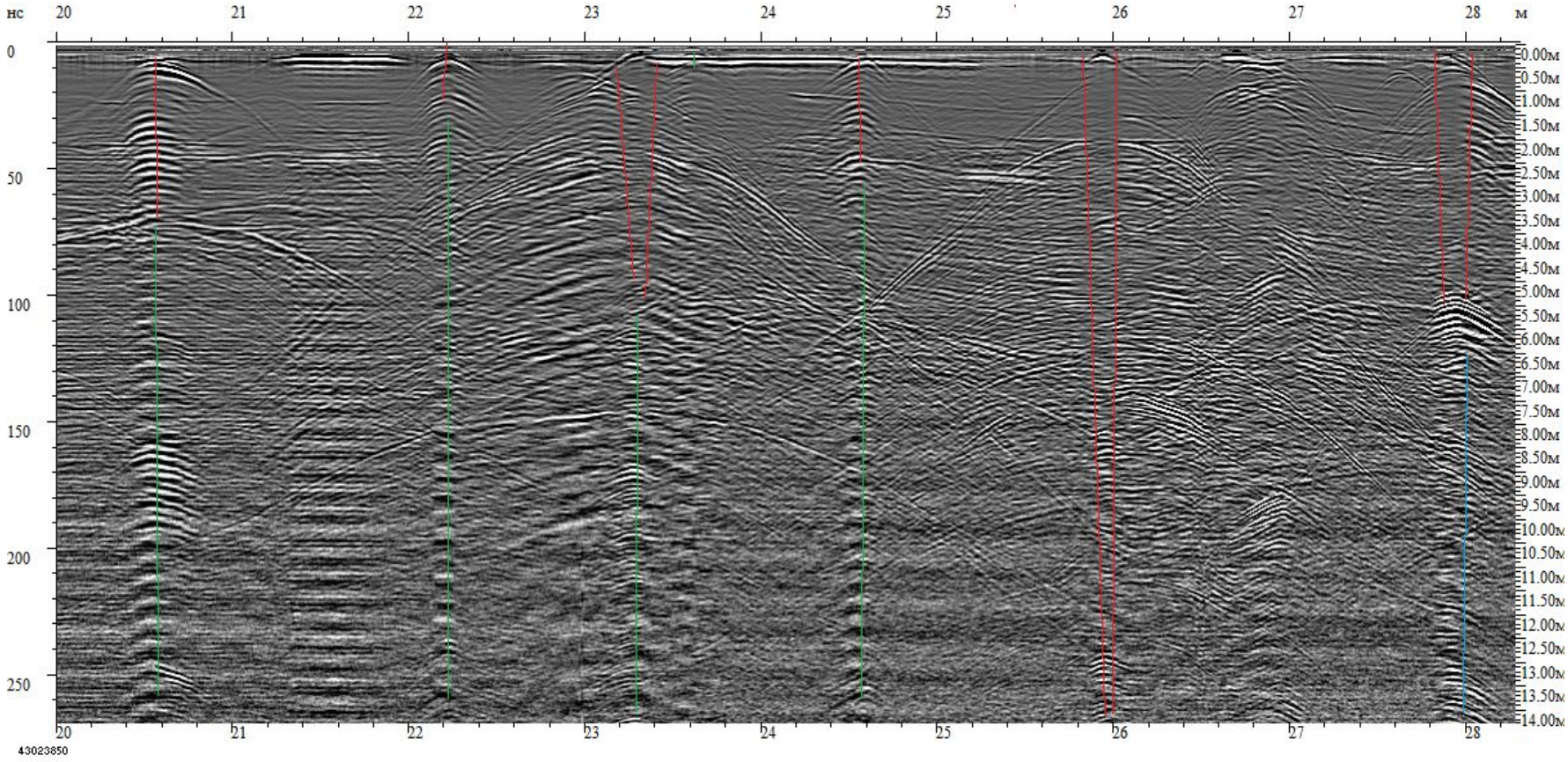
Figure 7. Scan over plastic container of rock fragments 25 mm to 50 mm.

Conclusion.

VOF improves the resolution of the simulated data, removing clutter from the original. The operation is also very fast over each A-scan data set, and allows construction of B- scans from the filtered data.

The resulting image can assist in determining the size and location of objects directly beneath the antenna.

Thank You!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