Autonomous GPR acquisition and diffraction imaging

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Autonomous acquisition
Autonomous acquisition

- improves accuracy
  - blends modern technologies (GPS, LIDAR, Wi-Fi)
- minimizes human error and safety hazards
  - operated remotely
  - requires fewer field workers
- maximizes efficiency
  - real-time data access
  - adaptability to sensor input
GPR → Wi-Fi antenna
Planned paths

20 loops

60 loops
Actual paths

20 loops

60 loops
Autonomous acquisition: future work

- establish new survey location
- continue Geobot development
- use GPR sensor input to guide acquisition
  - determine data target
  - develop real-time target detection
Diffraction imaging
Diffraction imaging

diffraction separation  diffraction focusing

imaging techniques:
- plane wave destruction
- hyperbolic Radon transform
- dip-angle gathers
Diffraction imaging

diffraction separation  diffraction focusing

imaging techniques:
1. plane wave destruction
2. hyperbolic Radon transform
reflection dips
positive / negative slope
reflection + diffraction dips

PWD diffractions
true diffractions
reflection + diffractions dips

positive / negative slope
reflection + diffraction dips

PWD diffractions
Hyperbolic Radon transform

\[ d = Lm \quad m = L^T d \]

**m**: model
**d**: zero-offset data
**L**: HRT operator
Hyperbolic Radon transform

\[ d = L \mathbf{m} \quad \mathbf{m} = L^T d \]

\[ \min_{\mathbf{m}} J = \| L \mathbf{m} - d \|^2 \]

\text{m: model}

\text{d: zero-offset data}

\text{L: HRT operator}
Hyperbolic Radon transform

\[ m(x, y, t_0, v) = \sum_{h_x} \sum_{h_y} d(x, y, t) \]

\[ t = \sqrt{t_0^2 + \frac{h_x^2 + h_y^2}{v^2}} \]

- \( h_x \): x-offsets
- \( h_y \): y-offsets
- \( v \): stacking velocity
- \( t_0 \): zero-offset traveltime
- \( t \): diffraction traveltime
HRT diffractions
true diffractions
PWD diffractions
PWD diffractions
Diffraction imaging: future work

- develop diffraction detection technique
  - refine hyperbolic Radon transform operator
  - investigate additional diffraction imaging methods
- implement diffraction guided acquisition