Subsurface Imaging of Road Pavement by Full Polarimetric MIMO GPR

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Radar Polarimetry and Polarimetric synthetic aperture radar(SAR) Imaging can expand radar capabilities. In spaceborne radar, full polarimetric SAR satellites have been operated by several countries and used to monitor targets such as natural disasters and vegetation. We have studied application of radar polarimetry technology to Ground Penetrating Radar(GPR) and we built a full polarimetric MIMO Ground Penetrating Radar (MIMO GPR) "X-Yakumo" in 2021 [1].

This GPR has 4 pairs of cross-polarization bow-tie antennas and polarization can be switched. The radar system is a stepped frequency continuous wave (SF-CW) radar that operates between up to 1.5 GHz. We have evaluated the fundamental performance of the full polarimetric GPR using a known buried target, the evaluation result shows the GPR can acquire a complete scattering matrix from the target. Also, reconstructing subsurface profiles from data acquired with all antenna combinations by SAR processing achieves high-precision 3D subsurface imaging.

We have shown that the complete scattering matrix acquired by the full polarimetric GPR can reproduced any polarization status by applying the polarimetric basis transformation. It will not only be possible to extend object detection performance but also the classification of the type of buried objects and the identification of subsurface conditions like full polarimetric SAR imaging.

Pauli decomposition is widely used for target detection and classification in radar polarimetry. We implemented the Pauli decomposition to full polarimetric GPR datasets and applied it to asphalt road GPR measurement data. Figure 1 shows the Pauli decomposed GPR B-scan (vertical) profile and surface condition of asphalt roads. Directions of polarization are defined that X being parallel to the GPR survey direction and Y being perpendicular to the GPR survey direction. Reflections from under the roads *XX*+*YY*(red) and *XX*-*YY*(blue) polarization, which are equivalent to single-bounce reflection and double-bounce reflection, are outstanding. On the other hand, these reflections are weaker in the section with cracks, such as in road (b) the distance 0 to 2 m.

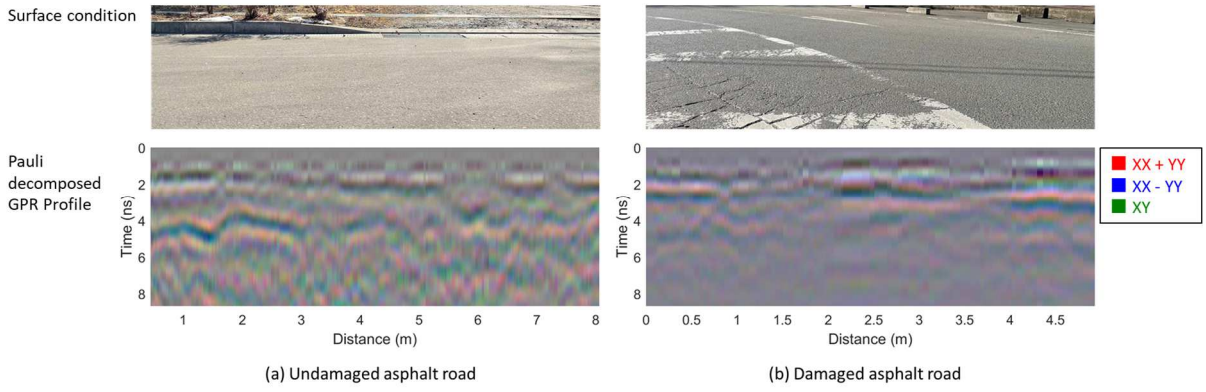

Figure 1. Pauli decomposed GPR B-scan (vertical) profiles of asphalt road GPR measurement.

References

[1] R. Saito and M. Sato, "Performance evaluation of full-polarimetric MIMO GPR," *Proc. IEEE International Geoscience and Remote Sensing Symposium*, Kuala Lumpur, July 2022.