VERMONT
AGENCY OF TRANSPORTATION

FACT SHEET

Remote Radar Inspection of Concrete Bridges for Moisture Estimation and Crack Depth Detection

PROJECT TITLE

Remote Radar Inspection of Concrete Bridges for Moisture Estimation and Crack Depth Detection

STUDY TIMELINE

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INVESTIGATORS

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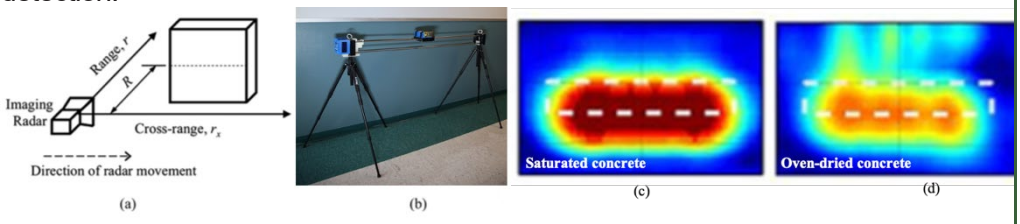
More information about the VTrans Research Program, including additional Fact Sheets, can be found at: http://vtrans.vermont.gov/planning/research

Problem Statement

Concrete cracking is the main cause responsible for the degradation of concrete bridges. Rapid growth of cracks in concrete can lead to sudden/brittle failures of concrete bridges. However, detection of crack depth in concrete bridges using efficient, nondestructive methods is a challenging task in the field. While existing electromagnetic (radar) sensors can generate electromagnetic waves (radar signals) to penetrate into concrete for subsurface sensing, their performance is significantly affected by the presence of subsurface moisture content in concrete. Meanwhile, moisture content in concrete also indicates the likelihood of other damages such as alkali-silica reaction (ASR) and steel rebar corrosion. To improve the performance of radar sensors for concrete crack depth detection, moisture effect in concrete must be investigated. To improve the efficiency in bridge inspection, a remote/non-contact radar sensor is needed for concrete crack depth detection.



(a) (b) (c) (d)

Methodology

We propose to i) quantify the moisture content in intact concrete, ii) model the radar image pattern of intact concrete at different moisture contents, iii) estimate the moisture content of cracked concrete using radar images, iv) extract the radar image pattern of intact concrete from the radar images of cracked concrete, and v) detect concrete crack depth from the radar images of cracked concrete. In our approach, remotely collected radar signals are processed by synthetic aperture radar (SAR) imaging algorithms to for subsurface sensing. A 10-GHz continuous wave compact, portable imaging radar sensor is used for laboratory tests and field inspection of concrete bridges. Deterministic and heuristic (e.g., artificial intelligence) pattern recognition techniques will be used for extracting the patterns in radar images. Concrete crack depth will be estimated by the scattering pattern in radar images.

Next Steps

In our data-driven research approach, we will develop the pattern/signature of intact concrete bridges at different moisture contents from field data collection. We will leverage our knowledge learned from laboratory concrete specimens to verify it with selected cracked concrete bridges, with suggestions from VTrans.

Potential Impacts and VTrans Benefits

This research provides VTrans a novel technology to efficient inspect concrete bridges using a compact portable imaging radar sensor that can be installed on an unmanned aerial vehicle (UAV) platform. The subsurface moisture content information of concrete bridges can be used as an early-warning indicator for proactive structural repair and asset management.