

EGU2020-1660

<https://doi.org/10.5194/egusphere-egu2020-1660>

EGU General Assembly 2020

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Mapping the Friction Coefficient of Asphalt Roads Using Airborne Imaging Spectroscopy

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The purpose of this study was to evaluate the realistic feasibility of using hyperspectral remote sensing airborne data for mapping asphalt road conditions. We constructed a real-life operational scenario, where the road's dynamic friction coefficient was modeled against the reflectance information extracted from the image. The asphalt pavement's dynamic friction coefficient was measured by a standardized technique, using a Dynatest friction-measuring system. The hyperspectral data were acquired by both the Specim AisaFENIX 1K and Telops Hyper-Cam airborne sensors at a selected study site, with roads characterized by different aging conditions. The spectral radiance data were processed to provide apparent surface reflectance and emissivity using ground calibration targets. Our final dataset was comprised of thousands of clean asphalt pixels coupled with geo-rectified in situ friction measurement points. We deployed a partial least squares regression model with the PARACUDA-II spectral data-mining engine, which uses an automated outlier-detection procedure and dual validation routines—a full cross-validation and an iterative internal validation based on a Latin hypercube sampling algorithm. Our results show prediction capabilities across the visible–near infrared–shortwave infrared (0.4–2.5 μm) spectral region of $R^2 = 0.72$ for the best available model in internal validation, and across the longwave infrared (7.6–11.4 μm) spectral region of $R^2=0.62$ for the best available model in internal validation. Both spectral regions (optical and thermal) maintained high significant results with $p < 0.0001$. Using spectral assignment analysis, we located the spectral bands with the highest weight in the model, and discuss their possible physical and chemical assignments. The derived model was applied back on the hyperspectral images to predict and map the friction values of every road's pixels in the scene. We conclude that although a relatively strong prediction model can be achieved, the imaging spectroscopy technique from airborne platforms) may open a new frontier in road safety and present a new capability for the promising airborne technology.