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OVERVIEW OF THE COMPUTATIONAL TESTBED FOR THERMAL IMAGING

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ABSTRACT

A high-resolution, computational suite has been constructed to produce synthetic thermal imagery of vegetated soil surfaces. The thermal infrared ground signatures are created from the coupling of models for the ground, vegetation, ray casting, and sensor characteristics to produce realistic thermal infrared simulated imagery. These resulting images provide information ranging from simple temperature contrasts to high-resolution images comparable to actual sensor images that can be used to evaluate or train automatic target recognition systems. Analyses of synthetic images are used to develop recommendations of optimal sensing strategies. All modeling and characterization occurs at the centimeter level scale, which requires massively parallel computation resources to meet the demands of the simulation.

The models run simultaneously on a single, parallel or serial computer and communicate using either sockets or file transfers. The soil model is a three-dimensional, spatially adaptive, continuous Galerkin, finite element model that simulates partially-saturated flow and heat transport, coupled to two-dimensional surface water flow. The vegetation model simulates infrared absorption, reflection, and transmission by discretized plant leaves and stems. Ray casting provides boundary conditions for the soil and vegetation thermal models, and produces multi-spectral images of energy reflected and emitted from the synthetic scene. The sensor model captures the blurring effects of atmosphere and sensor optics as well as correlated noise effects of the specific sensor. Subsurface phase change, distributed root zone moisture uptake and transpiration, and flow through macropores and cracks are processes under construction. The parallelization of the individual testbed components is relatively straight-forward. The central difficulty in achieving acceptable performance for the computational testbed in a parallel computing environment is the sequencing of data transfers between components.

Example calculations to be presented include a multi-million-element simulation for an arid test site that is only a few meters in its longest dimension. The models are driven with meteorological data and are built using material property data collected at the field site. Synthetic images produced are compared against those from thermal cameras. A long-term goal of this work is to help build inversion software to estimate ground state information (soil moisture and physical property distributions) from airborne imagery.