Fast Image Texture Classification Using Decision Trees

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Texture analysis would permit improved autonomous, onboard science data interpretation for adaptive navigation, sampling, and downlink decisions. These analyses would assist with terrain analysis and instrument placement in both macroscopic and microscopic image data products. Unfortunately, most state-of-the-art texture analysis demands computationally expensive convolutions of filters involving many floating-point operations. This makes them infeasible for radiation-hardened computers and space-flight hardware.

A new method approximates traditional texture classification of each image pixel with a fast decision-tree classifier. The classifier uses image features derived from simple filtering operations involving integer arithmetic. The texture analysis method is therefore amenable to implementation on FPGA (field-programmable gate array) hardware.

Image features based on the “integral image” transform produce descriptive and efficient texture descriptors. Training the decision tree on a set of training data yields a classification scheme that produces reasonable approximations of optimal “texton” analysis at a fraction of the computational cost. A decision-tree learning algorithm employing the traditional k-means criterion of inter-cluster variance is used to learn tree structure from training data. The result is an efficient and accurate summary of surface morphology in images.

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Constraint Embedding Technique for Multibody System Dynamics

This approach is applicable to multibody dynamics modeling of vehicles and robots.

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Multibody dynamics play a critical role in simulation testbeds for space missions. There has been a considerable interest in the development of efficient computational algorithms for solving the dynamics of multibody systems. Mass matrix factorization and inversion techniques and the $O(N)$ class of forward dynamics algorithms developed using a spatial operator algebra stand out as important breakthroughs on this front. Techniques such as these provide the efficient algorithms and methods for the application and implementation of such multibody dynamics models. However, these methods are limited only to tree-topology multibody systems.

Closed-chain topology systems require different techniques that are not as efficient or as broad as those for tree-topology systems. The closed-chain forward dynamics approach consists of treating the closed-chain topology as a tree-topology system subject to additional closure constraints. The resulting forward dynamics solution consists of: (a) ignoring the closure constraints and using the $O(N)$ algorithm to solve for the “free” unconstrained accelerations for the system; (b) using the tree-topology solution to compute a correction