General Research Fund -- Final Report

Proposal Title: Advancing Bio-Based Composites by Automated Image Analytics

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1. Summary of the Hypotheses:

Segmentation of digital images of bio-based composite materials acquired via high resolution X-ray computed tomography (CT) is expected to lead to major breakthroughs in material-science research. Image segmentation of such CT images includes: (1) Partitioning of the image into distinct texture parts corresponding to different morphological properties of the composite material; and (2) Detection and segmentation of the texels defining each discovered texture, where the texels correspond to particles embedded within the composite. Therefore, image segmentation is expected to support automatic morphological characterization of complex, anisotropic, and heterogeneous nature of particulate bio-based composites.

2. Scholarly Work Performed Using the GRF Support

A fundamental problem in computer vision is to partition an image into meaningful segments. The key research contribution of the work performed using the GRF support is the design and implementation of a novel image segmentation framework for including end-users in computation. Our framework represents a departure from the traditional methods, which typically segment images without considering domain knowledge, and access to user feedback. The results of our work were presented in the M.S. Thesis, entitled "Analysis of Bio-based Composites for Image Segmentation with the Aid of Games", of Jennifer Inouye in the School of EECS, College of Engineering.

Our work considered two key tasks, as explained in the following subsections.

2.1. Providing Ground-Truth Image Annotations for Evaluation of Segmentation

Given a set of CT images of three different composite materials, we created a database of annotated images for all the image regions of interest -- i.e., particles in the imaged composite materials. The annotated images can be used for evaluating the accuracy of segmentation algorithms. Because of how time consuming and mundane image annotation is for a person to do, we cast this task into a game. The game was aimed at

making the annotation task easier. In general, a game engages imagination, creativity, fellowship of all subjects involved. We studied games that can be played on the internet by many people, like those in Amazon Turk, so that the broader public could get involved. One Master's student in computer science, and two high school students from the ASE program were involved in the design of the game, which engages a number of people to accomplish a meaningful task (i.e., in this case, image annotation), and are willing to do so because it is fun. It was shown that software tools developed for the game can aid in image annotation in terms of making it faster, more accurate, and more cost effective than traditional methods.

2.2.Implementation, and Evaluation of Segmentation Algorithms

We implemented and evaluated two standard image segmentation algorithms -- namely, Ncuts and Meanshift -- on images of three types of composite materials, including Particle board (PB), Oriented strand board (OSB), and Wood plastic composites (WPC). PB consists of pressurized word particles with adhesive, which we identify as the light colored ‘blobs’ within the image. OSB consists of different strands of wood layered in different directions. WPC is made of wood fiber and plastics. Our preliminary study demonstrated that Ncuts and Meanshift give relatively poor results on these images. We identified key reasons for poor performance of these standard segmentation algorithms, and provided insights into future research direction toward improving performance.

3. Additional Work the GRF Funding Made Possible: Acquisition of New CT Images of Composite Materials

We also worked on collecting new microCT images of particleboards and fiberboard furnishes. We used 132 hours of scanning time in the Laboratory for Nano- and Micromechanics of Biological and Biomimetic Materials. The images have much better properties, and thus segmentation algorithms are likely to perform better on them relative to our existing images.

4. Expenditure of the GRF Funds

In 2011, the GRF funds in the amount of $5048.00 were used for supporting hourly work of Jennifer Inouye on her Master's thesis in the School of EECS, College of Engineering.

Also, in summer 2011, the GRF funds were used for supporting the hourly work of two high school students -- namely, Anita Chow from Salem, OR, and Casey Schafer, Corvallis, OR -- who participated in the ASE Saturday Academy outreach program. We also had to pay for software licenses, printing expenses, and computer maintenance. The costs were: $3000.00.

The GRF funds were also used to pay for 132 hours of microCT scanning time in the Laboratory for Nano- and Micromechanics of Biological and Biomimetic Materials. The

costs were in euro, converted to US dollars: $1900.00 for scanning + $30 bank wire transfer.

5. External Funding Requests as a Result of the GRF Funding

2011: Grant proposal for NSF IGERT program in collaboration with the Oregon Nanoscience and Microtechnology Institute (ONAMI) and the Sun Grant Initiative