Deformable Model-based X-ray CT Image Segmentation for Automatic Phenotype Identification in Laboratory Mice

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Background: The Oak Ridge National Laboratory has a world class mammalian genetics research facility that houses about 92,000 mice representing about 1000 mutant strains. Mutagenesis experiments are performed on the mice to introduce changes in the genetic code. The physical manifestations (phenotypes) of these mutations are important to determine but are often difficult to find especially when only a few researchers are available to screen a large number of mice. Approximately 50% of these phenotypes are expressed as skeletal deformities (e.g. scoliosis) that cannot be seen without sacrificing the mouse. A significant percentage of the remaining mutations also show up as other internal deformities such as misshapen organs.

Methods: To accommodate the mice screening needs of the biologists at ORNL, a Laboratory Directed Research and Development (LDRD) program has been ongoing to develop a small animal, high-resolution micro-CT scanner (MicroCAT) that generates 3D x-ray tomographic images of mutagenized mice. Automatic identification of phenotypes via analysis of the 3D x-ray data is an important part of the mouse screening process. A few key phenotypes have been identified that would be very useful to automatically detect. These include, for example, brain protrusions and polycystic kidney disease. Deformable models are used extensively in medical image analysis applications because of their flexibility and effectiveness. A statistical-based deformable model technique has been adopted and is being modified for application to the x-ray data for the purposes of (1) segmenting and identifying the organ(s) of interest (e.g. brain and/or kidney) and (2) detecting the presence or absence of a phenotype as expressed by the measured physical characteristics of the segmented organ.

Results: After a brief discussion of deformable model techniques, some work-in-progress segmentation results will be presented that show the potential for success of statistical-based models in this application. The particular phenotype of interest that has been focused on to date is polycystic kidney disease. In addition, results will be presented that illustrate the need for additional research to improve the performance of these statistical-based deformable models. These areas of current research will also be outlined.

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