ESRF - Experiment report

High resolution 3D dynamic atlas of rat anatomy
MD 360
ID17
Round 4/2008

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Goal and context:
The goal of this experiment was to acquire full body scan of rat anatomy to obtain accurate 3D reconstruction of organs. The experiment took place at ID17 for its ability to allow imaging large samples at high accuracy. Typically a cylindrical spanning 25cm height and 10cm diameter was required for a rat.

Report of experiment:
During the three days of experimentation at ESRF, four rats have been analyzed. Each rat has been sacrificed 30 minutes before the scanning. The body was fixed in a sample carrier made of polycarbonate tube. Limbs and teeth were attached to the tube using surgery wire, directly tied through digit and around teeth. A polystyrene cube was inserted to stabilize the sample. Each body has been fully scanned in 5 separated stacks with an isotropic accuracy of 55 microns. Reconstruction of the volume of slices has been done on site using ESRF software. Approximately 1Tbyes of data has been collected.
The quality of the team at ID17 has been remarkable for its professionalism. We address thanks to Christian Nemoz for assisting in the scanning, Paul Tafforeau for helping in the calibration, Dominique Dallery for the assistance with animals, Thierry Brochard for the sample setup, Antonio Bravin and Geraldine Le Duc for the management of this project at ESRF.

Experiment results:
The experiment has been a success as the samples was stably scanned, despite the rotation of the sample per stack and the translation between stacks. For each rat, all the 5 stacks were successfully gathered as a single volume with no noticeable artifacts in the reconstruction. Skeletal tissues, skin interface and even fur (figure 1) have been clearly identified. It is to notice that each fur hair could be almost identified individually, allowing for study of fur reflectance in the future. Muscle tissue could not be identified due to poor interface resolution. This result was expected and was not a failure. Further experiment with contrast agent could remedy to this and allow an even deeper investigation of anatomical structure. Finally, with respect to comparison with other standard microCT facilities, the monochromatic property of the ESRF beam allowed a much better image quality.

Scientific results:

The primary expected result was to obtain scans of the skeleton structures with accuracy high enough to separate moving individual bones. The accuracy of 55 microns showed to be successful in this task. This accuracy was required and not over-estimated as we have identified separation between some bones structure (vertebras, carpal and metacarpal bones), being sometimes as small as three pixels. A paper reporting the skeleton alignment between the rats has been published at Computer Graphics Forum (Gilles et al., 2010). In this paper, skeleton of the four rats, set in different pose, are successfully geometrically aligned, allowing further analysis of geometrical comparison (figure 2).

Another part of anatomical investigation has been done on the vestibular system. Again, the quality of the results allowed to successfully identified organs such as the semi-circular channel of the inner ear (figure 3). A paper exploiting these results is currently under preparation.

The exploitation of the scans is still under process and other projects, especially in biomechanics, are currently under investigation.

B. Gilles, L. Revéret, D.K. Pai, “Creating and animating subject-specific anatomical models”, Computer Graphics Forum, 2010.

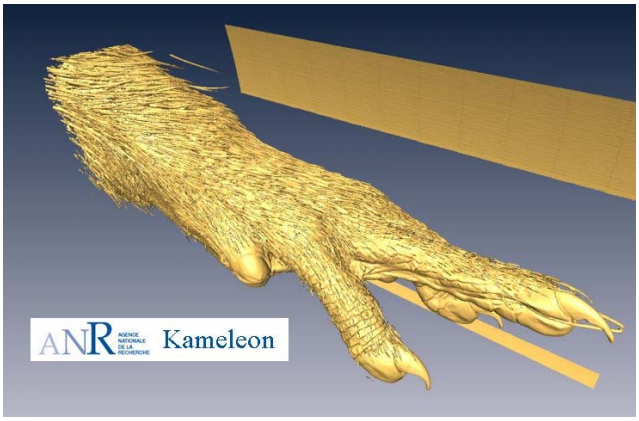

Figure 1. Fur details

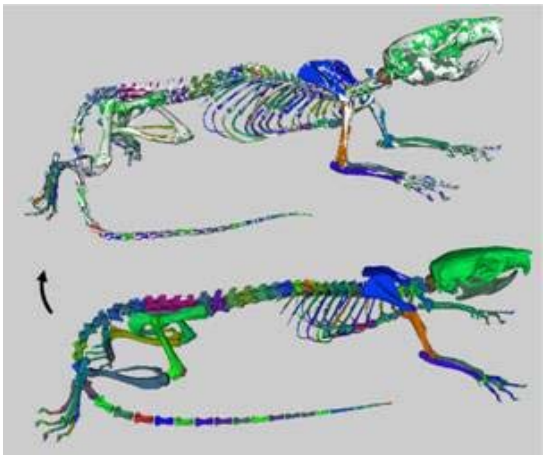

Figure 2. Skeleton alignment

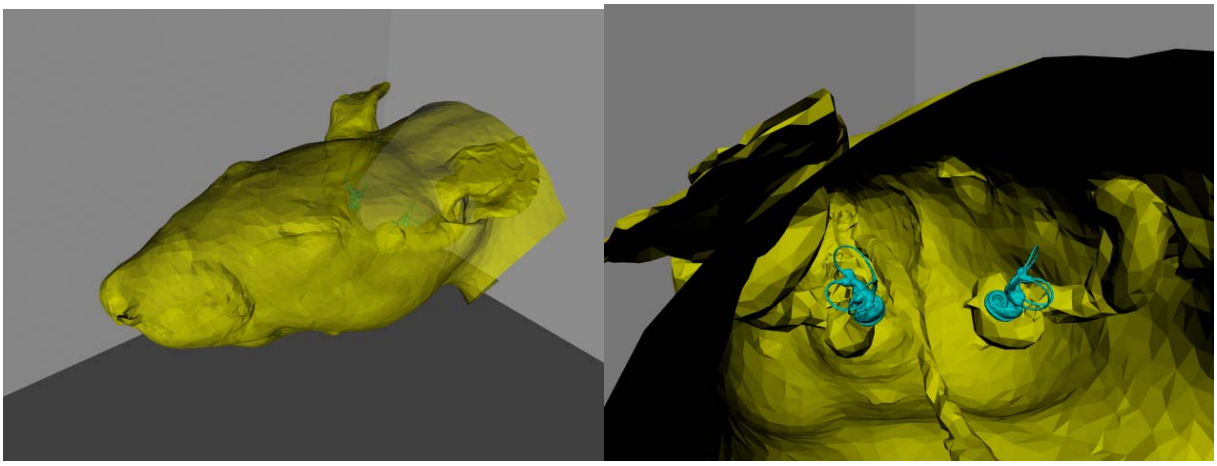

Figure 3. Detail of inner ears