Developing a system for the molecular imaging of freely moving rats

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Using molecular imaging to obtain time-activity data from the organs of living animals that are free to move, behave and respond to stimuli is a tantalising prospect for preclinical investigations. Here we report the current status of a system designed in our laboratory to realise this goal in positron emission tomography (PET) of rats.

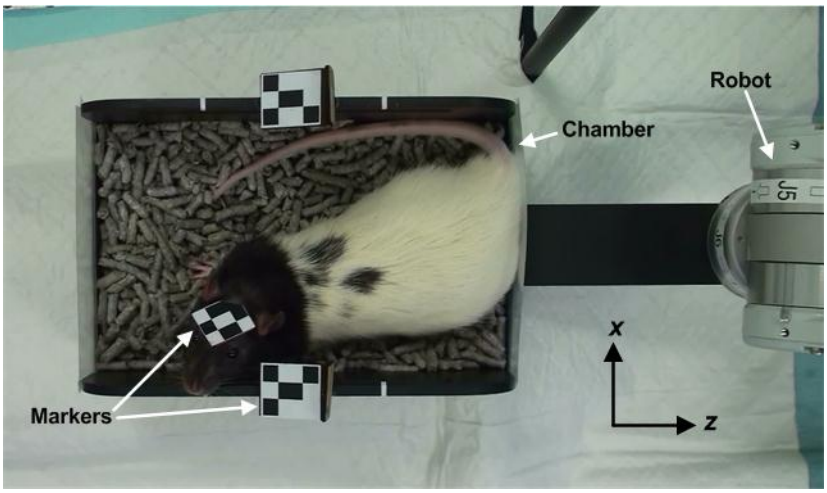
Imaging a freely moving animal in a narrow axial field of view (FOV) scanner is facilitated by robot-controlled adjustment of the animal chamber. Slow, smooth compensatory movements of the chamber based on the animal's position maintain the head centrally in the FOV over 80% of the time.

Motion estimation is performed using multi-camera optical tracking of either an attached marker or alternatively of native features on the animal. The latter approach is simpler to perform, less invasive, and removes the risk of marker detachment. Moreover, in phantom studies involving a taxidermied rat head, the method resulted in motion estimates that were ten times more accurate than marker-based estimates. A method to correct for refraction-induced error resulting from motion tracking through a transparent chamber has also been developed to improve the accuracy of motion measurements.

To reconstruct PET data corrupted by motion, a fully 3D list mode algorithm with built in motion compensation is under development. This algorithm has been validated in digital mouse phantom simulations with realistic head motion.

Also under development is partial volume correction based on an anatomical rat atlas which is kept in constant alignment with the known, changing pose of all/part of the animal. This correction is likely to be necessary for proper quantification of uptake and time-activity data in organs or regions-of-interest in rats and mice.

In conclusion, a system for motion-compensated PET imaging of awake, unrestrained rats is being developed and we have successfully trialled the data acquisition aspects of the system in two pilot studies with freely moving rats. Further work is required to develop attenuation and scatter correction methods to deal with variations in body pose as the animal moves around the chamber.



Freely moving rat inside the motion-adaptive chamber. The chamber attaches to a robot and is adjusted in the horizontal (*x*-*z*) plane to maintain the head near the centre of the scanner FOV. Here, attached markers on the head and chamber are being used for motion tracking.