Activated Voxels Increase 3.5 Times with Commercially Available Small Footprint Motion System in MRI

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Target audience: FMRI researchers and experimenters.

Fig.1. Optical tracking camera, IR illuminator, monitor and recording palmtop located outside of magnet bore.

Purpose: Head movement is a critical issue for fMRI, as motion on the order of voxel resolution will degrade the data. Motion becomes even more critical for high-field, high-resolution methods and is especially problematic for the study of awake animals [1], in this case of dogs. Even the best-trained dogs inevitably will make some slight motion or quivering. The presented approach utilizes SPM plus scanner-independent motion measurement to improve retrospective compensation.

Methods: An optical tracking system [2] based on a single camera was used to monitor and record motion parameters. The single camera optical tracking system is an MRRA Inc. model HT-1000 comprised of an infrared radiation transmitter, an optical camera with built-in DSP processor, a dot reflector, a monitor and a palmtop computer (Fig.1). The infrared transmitter gives off rays invisible to the subject that are reflected by the dot reflector mounted on the dog's head; the optical camera picks up the reflected IR light, shaping a photo and calculating the change in dot position. Next the camera digitally transmits the position data to the computer. The dot reflector is a round white retroreflective tape of 3cm diameter, with one side for gluing to the dogs skin. The video monitor allows the operator to check for proper image framing, and the palmtop computer records the position co-ordinates of the center of the dot reflector, as well as its area, which are used as regressors of no interest in the activation analysis after correcting for motion using image transformation based realignment. The dogs were trained to keep their heads almost as still as humans to restrict large-scale movements (Fig.2), which cannot be compensated retrospectively. While the optical head motion tracking eliminates smaller and jerky movements, especially in the x-y plane. A Siemens 3T Verio scanner was used with a human knee coil as a dog head coil. T2 weighted functional images were acquired using EPI sequence for BOLD contrast. Data from 17 awake dog sessions of 28 runs were obtained. Each run consisted of 5 blocked trials of 10s odorant stimulus [3], with a fixed interval of 30s in between. Anatomical images were acquired using MPRAGE.

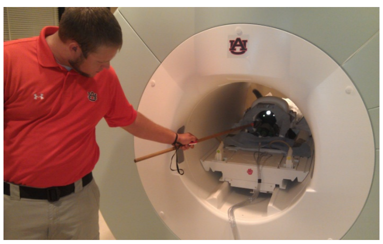

Fig.2. Dog with head positioned in MRI knee-coil. Trainer holds fixation target on end of wooden stick. Dog eyes show as two white dots. Larger white dot is retroreflective target adhered to dog's head.

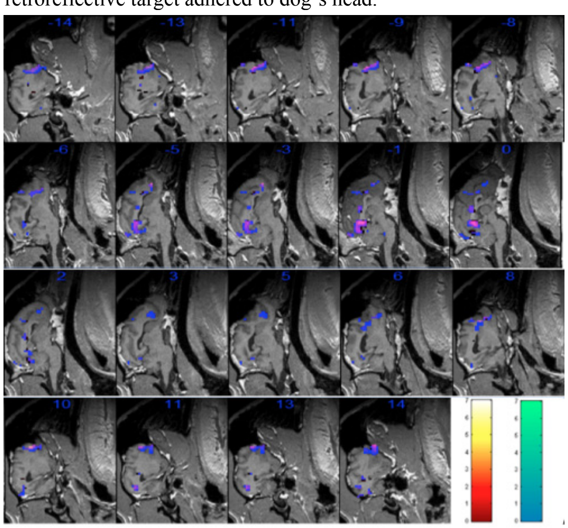

Fig.3. Activation map obtained with only SPM realignment parameters (without camera motion parameters, hot colormap), and with camera motion parameters as well as SPM realignment parameters as regressors (winter colormap). Overlap area is displayed as purple. Number of voxels activated with SPM motion regression is 171. Number of voxels activated using both SPM and camera motion regression is 591. Overlap area has 167 voxels.

Result and Discussion: The results obtained with integration of optical head tracking parameters showed the same basic activation pattern obtained using only SPM realignment, but also additional areas of activation in the frontal cortex, olfactory bulb, and cerebellum. These areas are important areas involved in olfactory processing. 171 voxels were activated during the olfactory testing using only SPM alignment, and 591 voxels were activated using SPM plus camera motion. The overlap between the two methods was 167 voxels (Fig.3). These additional activations show the efficacy of this optical motion tracking system, especially for eliminating effect of jerky movements. The optical head tracking system was detached from the scanner, thus not suffering problems such as vibration suffered by mount-in-bore camera systems [4, 5].

Conclusions: Incorporation of a separate optical motion tracking system increased measured activation volume by 3.5 times over only SPM compensation in awake dogs during an olfaction protocol in fMRI. This optical tracking system is expected to monitor 6-degree movement in future development.

References: **1.** Peeters R. (2001) "Comparing BOLD fMRI signal changes in the awake and anesthetized rat during electrical forepaw stimulation," Magnetic Resonance Imaging, vol. 19, pp. 821-826. **2**. Wildey, C.R. (2011) "Single-camera motion measurement and monitoring for magnetic resonance applications," Applied Optics, vol. 50, no. 14, pp. 2088-2097. **3**. Vodyanoy, V.J. (2005) "Apparatus and method for the measurement of the aerodynamics of olfaction in animals and man," US Patent 6,979,298. **4**. Qin, L. (2009), "Prospective head movement correction for high resolution MRI using an in-bore optical tracking system," Magnetic Resonance in Medicine, vol. 62, pp. 924-934. **5**. Tremblay, M. (2005), "Retrospective coregistration of functional magnetic resonance imaging data using external monitoring," Magnetic Resonance in Medicine, vol. 53, pp. 141-149.