# FEASIBILITY FOR USING MULTI-SLICE CT, MOTION CAPTURE, AND 3D COMPUTER ANIMATION TO MODEL JOINT MOVEMENTS IN WORKING DOGS

J.C. Jones,[1] J.C. Tan,[2] T.J. Tucker,[3] B.J. Pierce,[1] J.L. Foxworth,[3] D.C. Dinkins,[2] B. Long,[3] C.L. Hatfield,[1] T.A.M.Harper[1]

[1]Virginia Tech, Virginia; [2]Wake Forest University School of Medicine, North Carolina; and [3]Winston-Salem State University, North Carolina

## Introduction

Working dogs perform vital functions that include explosives detection, drug detection, law enforcement, patrol and sentry, search and rescue, fire accelerant detection, and tracking for missing persons. Early diagnosis and treatment of joint-related disability is critical for minimizing loss of man-hours, financial investment, mission readiness, and muscle mass in these valuable animals. In humans, 3D computer animation techniques designed for video games and movies have been adapted for computer-assisted learning, [1], radiation therapy planning, [2] and complex joint movement analyses. [3] [4] [5] The purpose of this study was to determine whether multi-slice CT, motion capture, and 3D computer animation techniques are feasible for modeling joint movements in working dogs. The long-range goal of our research is to develop improved methods for localizing joint pain in working dogs and measuring effects of targeted treatments.

## Acknowledgements

Wake Forest University Center for Biomolecular Imaging and Institute for Regenerative Medicine, Winston-Salem State University/Wake Forest University Human Performance and Biodynamics Laboratory, Montgomery County Sheriff's Office, and Mr. Terry Lawrence.

## Methods

**Aim 1:** Develop CT image data collection, motion capture data collection, image analysis, and 3D computer animation techniques using a rat.

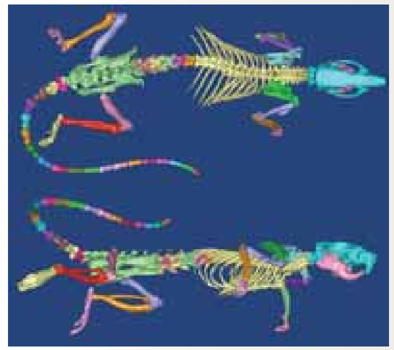

**Figure 1a.** An adult rat was placed under anesthesia and a whole body CT scan was acquired using a 16-slice CT scanner. Image data were imported to a TeraRecon image analysis workstation and Mimics software was used to create 3D images of skeletal structures. Segmentation tools were used to divide skeletal structures into separate functional units.

**Figure 1b.** Ten days after CT scanning, the rat was placed into a Plexiglas cage and markerless motion capture images of his exploration movements were acquired using three digital video cameras.

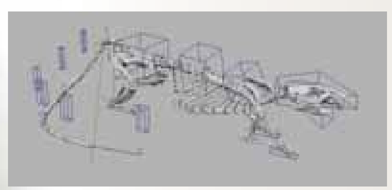

**Figure 1c.** Image data from the CT scan and motion capture were merged and analyzed using a 3D visualization workstation and 3D modeling software. Data were then converted to Stereolithography (STL) format and imported into computer animation software (Autodesk Maya and Motionbuilder) to create a rat skeleton that could be rigged with an Inverse Kinematic (IK) skeleton and animated frame by frame using motion capture videos as reference.

**Figure 1d.** The final scene was then analyzed using Autodesk Maya rendering software to generate an animation video clip of the rat's exploration movements in the Plexiglas cage. Reflections and shadows were added using Autodesk Mental Ray animation software.

**Aim 2:** Test and refine CT image data collection, motion capture data collection, image analysis, and 3D computer animation techniques in a working dog.

**Figure 2a.** A volunteer dog-handler working team was recruited. The dog was fitted with a body suit and reflective markers were attached to the head, spine, tail, and legs. Motion capture images were recorded using ten, high speed digital cameras and tracking software while the dog performed movements routinely required for his patrol and drug-detection tasks (flat work, stair work, and searching high). Two floor-mounted digital video cameras were used for cross-analyzing the movements. Movements were recorded at 120 frames/sec. Ground reaction forces were also collected using AMTI force plates, sampled at 960 samples/sec.

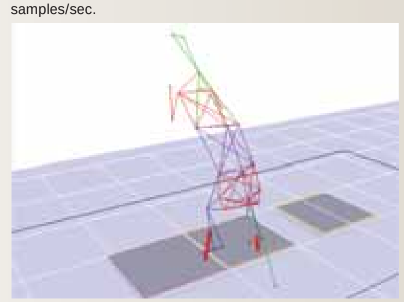

**Figure 2b.** Documentation of reflective marker recording was performed using Cortex software. Ground reaction forces were also recorded (red arrows).

**Figure 2c.** Two hours after motion capture data collection, the dog was sedated and a whole body CT scan was acquired using a 16-slice CT scanner. Functional units for the dog's skeleton were created using CT image data and 3D segmentation techniques previously developed in the rat.

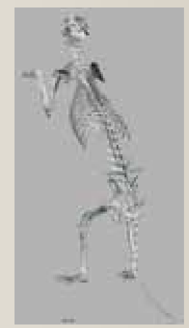

**Figure 2d.** Image data from the dog's CT scan and motion capture videos were merged, analyzed, converted to STL format and imported into computer animation software using the protocols previously developed in the rat. Motion data were also imported as FBX files. The IK chain was constrained to the marker points to add movement before rendering the data to a movie clip.

**Figure 2e.** Final 3D computer animation video clips of the dog's movements during working tasks were created using Autodesk Maya rendering software. Shadows were added using Autodesk Mental Ray animation software.

## Results

Computer animation videos of the rat and working dog were successfully created, each demonstrating 3D images of joint movements during exploration and work activities. The skeletal movements could be viewed from multiple angles as movie clips. Reflective marker data for the dog's front legs were lost due to failure of marker adhesive during motion capture of work activities. Some marker data were also lost due to superimposition of the handler between the dog and recording cameras. This necessitated manual addition of some skeletal structures in the computer animations. Strike force measurements for the working dog's flat work and stair work were inconclusive due to multiple foot strikes that occurred on force plates.

## Discussion / Conclusion

Findings from this study indicate that multi-slice CT, motion capture, and 3D computer animation are feasible techniques for visualizing and modeling joint movements in working dogs. The use of isotropic CT data greatly increases the accuracy of joint movement assessments in computer animations, because actual bone structures can be used instead of commercially available models. For future studies, further refinement of marker placement and force plate recording procedures is needed. Recording of the dog's movements while off-leash may also be beneficial.

## References

1. Kobayashi, M., et al., Three-dimensional computer graphics for surgical procedure learning: Web three-dimensional application for cleft lip repair. Cleft Palate Craniofac J, 2006. 43(3): p. 266-71.
2. MacKay, R.I., et al., Animation and radiobiological analysis of 3D motion in conformal radiotherapy. Radiother Oncol, 1999. 52(1): p. 43-9.
3. Baillot, Y., J.P. Rolland, and D.L. Wright, Automatic modeling of knee joint motion for the virtual reality dynamic anatomy (VRDA) tool. Stud Health Technol Inform, 1999. 62: p. 30-5.
4. Green, J.K., et al., Three-dimensional modeling and animation of two carpal bones: a technique. J Biomech, 2004. 37(5): p. 757-62.
5. Enciso, R., et al., The virtual craniofacial patient: 3D jaw modeling and animation. Stud Health Technol Inform, 2003. 94: p. 65-71.