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


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1Introduction

Working dogs perform vital functions that include explosive detection, drug detection, law enforcement, patrol and sentry, search and rescue, the acrobatic, 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] 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.

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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 small head CT scan was acquired using a Skyscan CT scanner. Image data were imported to a commercial image analysis and Amira software was used to create 3D models of cortical structure. Segmentation tools were used to divide the model into separate functional units.

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

Figure 1c. Three days after CT scanning, the 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 software. Segmentation tools were used to divide skeletal structures into separate functional units.

Figure 1d. The final scene was manufactured using Autodesk Maya modeling 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 evaluate 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 collar and reflective markers were attached to the head, spine, tail, and legs. Motion capture images of the dog working were acquired using three digital video cameras.

Figure 2b. Documentation of reflective marker recording was performed using Cortex software. Ground reaction forces were also recorded using AMTI force plates, sampled at 960 samples per second.

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. The dog’s CT scan and motion capture images were merged, analyzed, converted to Stereolithography (STL) format and imported into Autodesk Maya animation software. The IK chain was constrained to the marker points to add movement before rendering the data to a movie clip.

Figure 3a. The visualization of effective marker recording data points was created using Autodesk Maya modeling software. Reflective marker data for the dog’s front legs was lost due to failure of marker adhesion during motion capture of work activities. Some marker data were also lost due to superimposition of the handler and recordings. The unexpected manual addition of some skeletal structures in the computer animation.

Figure 3b. 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, radiation therapy, and 3D computer animation are feasible techniques for simulating and modeling joint movements in working dogs. The use of analogous CT data greatly increases the accuracy of joint movement assessments in computer animation. To accurately reproduce the canine 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


