Equine Trust Summer Scholarship

Development of 3D gait model

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Supervisor: Dr Robert Colborne

In 2015, The Equine Trust funded the purchase of a 6-camera infrared kinematic system which, together with a force platform and Visual3D modelling software, makes up a 3D gait analysis system to study animal locomotion. This is a new capability for Massey University, and so the main purpose of this Summer scholarship was to develop the 3D morphometric model in Visual3D, and to collect pilot gait data.

Nicola Wichtel, a Vet student who had completed third year at Massey, was hired into this Summer scholarship position. She worked alongside Andrew Weller, a recent graduate who had held a Summer position previously to develop our capability with the AnyBody musculoskeletal modelling package. The Equine Trust has recently funded a project to evaluate the equine limb's response to variations in riding surface stiffness, and so the other part of the Summer's activity was geared toward developing the equine forelimb model with a CT scan of a forelimb and assessment of the muscle parameters that contribute to the calculation of a muscle's physiological cross-sectional area.

Nicola spent the first two weeks of her scholarship in the anatomy lab, dissecting the individual muscles of the cadaveric limb we had CTed and measuring muscle masses, pennation angles, muscle fibre lengths, and cross sectional areas. Then, she moved to learning the Qualisys and Visual3D packages and started collecting kinematic and force data from a walking horse in the lab.

The lab, with Kistler force platform in the middle of the runway, and three of the 6 Qualisys cameras located on each side of the force platform.

We started by collecting kinematic data with marker clusters on the forelimb. This should have been a relatively easy job, but through trial and error over several days, we discovered that two of our six cameras had faulty infrared filters that were causing markers to merge and which therefore prevented calculation of good marker positions in three-dimensional space.

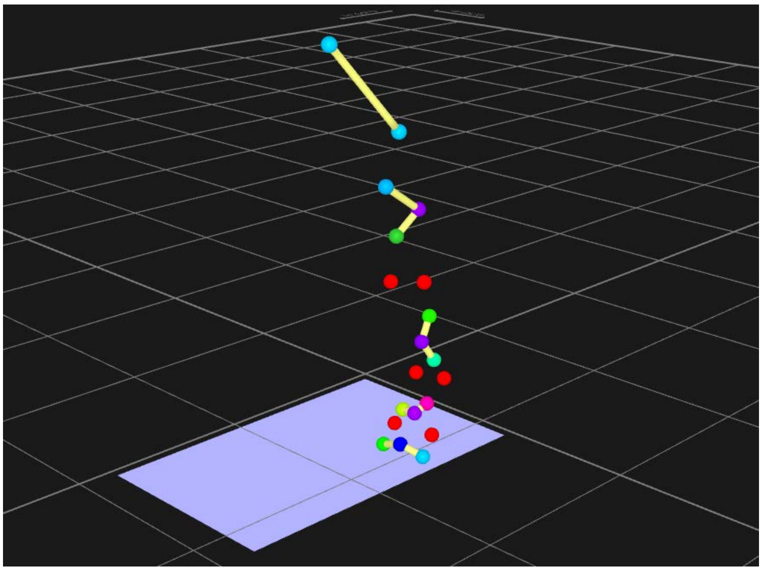


Fig. 1 - Marker clusters on the segments of the forelimb, with additional (red) markers on the medial and lateral aspects of the limb joints to assign axis locations. Segments are: hoof, pastern, metacarpus, antebrachium and brachium.

After sorting out that problem, which involved having the Qualisys technician visit for a day, we successfully collected good gait data. The first step was to attach markers on the limb segments (Fig 1) to identify their 3D movements during gait, and also markers on the medial and lateral aspects of the limb joints at their centres of rotation, to identify the joint axis locations. After collecting static images of the entire marker set, the joint calibration markers could be removed, and gait data collected from just the segmental marker clusters (Fig 2).

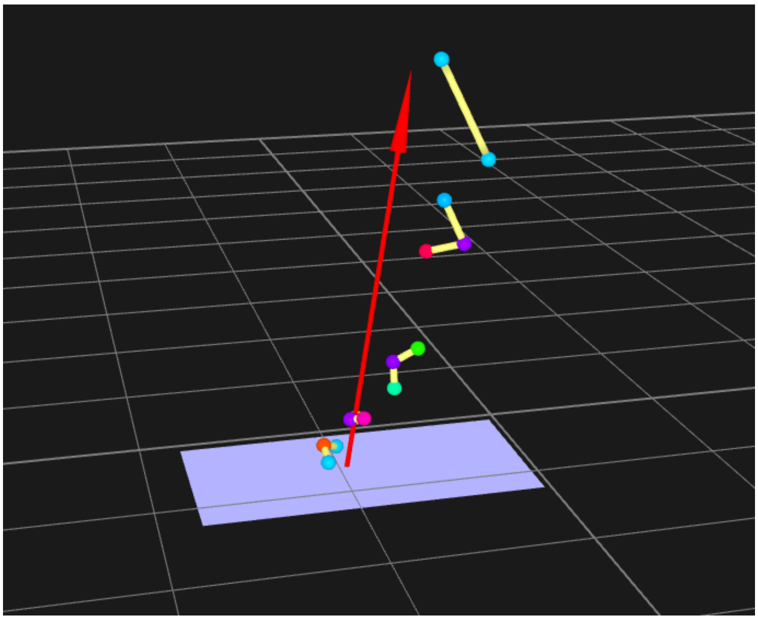


Fig. 2 – Markers on the forelimb segments during a gait trial. The red arrow is the resultant ground reaction force vector, coming up from the force platform, and located at the centre of pressure under the hoof.

The next step was to build a 3D model of the limb in Visual 3D, using segmental morphometric data from the literature. The limb segments were defined as either cylinders or as frustra, with their 3D joint axes defined orthogonal to the line through the medial and lateral markers put on the joints for the calibration. Segmental morphometric data includes centre of mass location and mass moment of inertia.

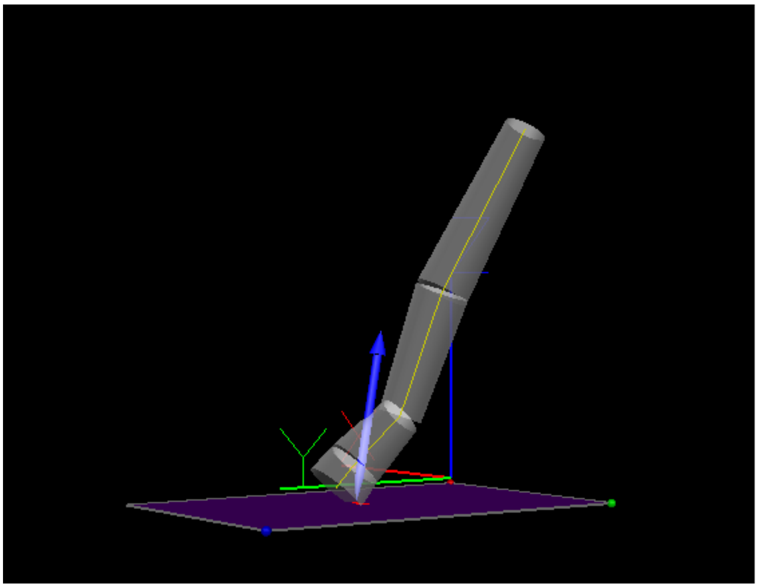


Fig. 3 – Forelimb segments defined as geometric frustra or cylinders.

Finally, and mostly for show purposes, we could input the bones of the limb to represent a real-looking limb with markers.

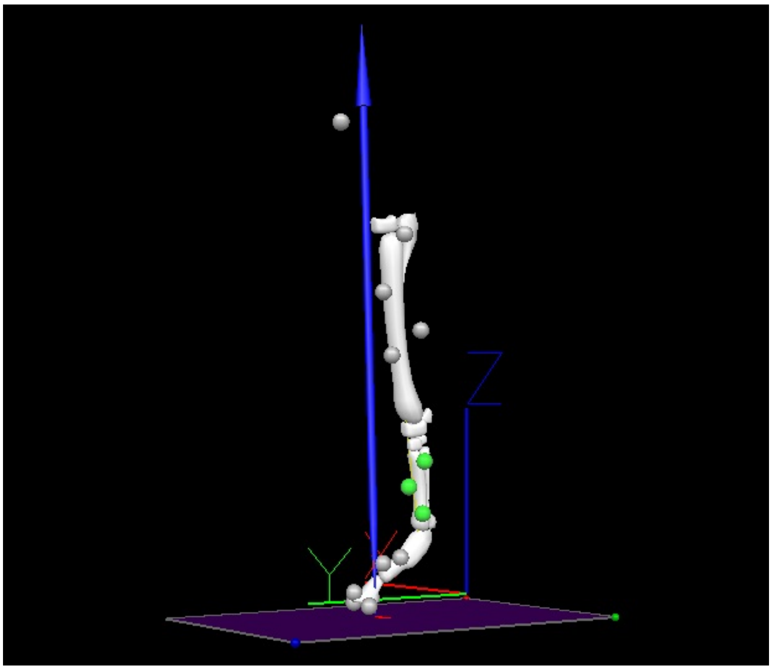
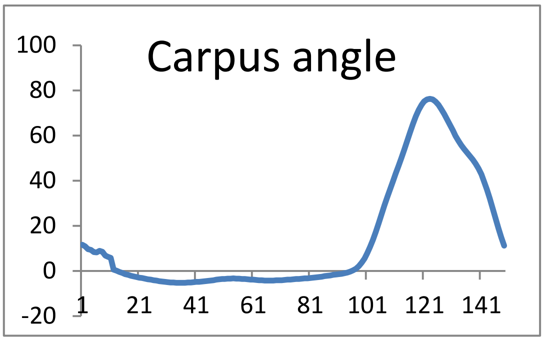
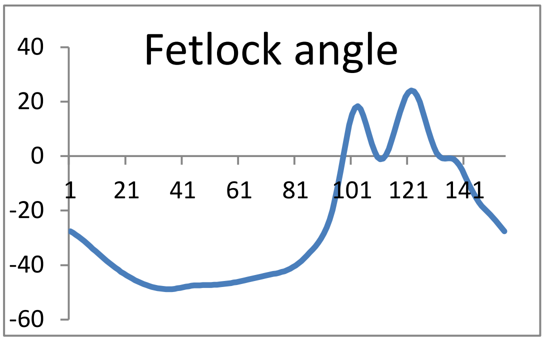


Fig. 4 – Forelimb segments with the geometric segments replaced by bones. The blue arrow is the resultant midstance ground reaction force.

With the segmental motions around the joint axes defined, we can display the joint angular excursions. The examples below are flexion-extension around the joint's transverse axis.





We now have the template for the equine forelimb constructed, and have some pilot data collected.

<u>A message from Nicola:</u>

The 8 weeks I spent working on this project gave me an appreciation for the usefulness of objective gait analysis progams. Lameness evaluations of horses in a clinical setting are typically nothing more than a subjective appraisal by the observer. The use of biomechanical modeling software to quantify the kinetics and kinematics of the limbs in motion provides a much more objective evaluation of the patient. The rudementary model we generated will be able to serve many purposes from lameness examination, to investigations into the effects of different surfaces, shoeing techniques, riding styles, etc.

As someone who is intending on going on to work in equine practice, I am pleased to have had the opportunity to delve deeper into the realm of gait analysis. The skills I have acquired through this project will help me immensely when I'm finally released into the real world. Through self-directed learning and many hours of tutorials I was able learn something new at every stage of the project. Furthermore, my many hours in the anatomy lab dissecting the equine lower limb gave me a very much needed and meticulous anatomy review lesson. I have truly explored the equine limb from the inside out. I now feel confident in my understanding of the limb in motion, and hope to apply and build on this knowledge in my future work.

I believe there is an exciting future ahead for the clincial and research applications of biomechanical modeling, and I am excited to have been part of these early days. I hope to continue this work in the future.