

Visualization of Canine Gait Using Optical Motion Capture

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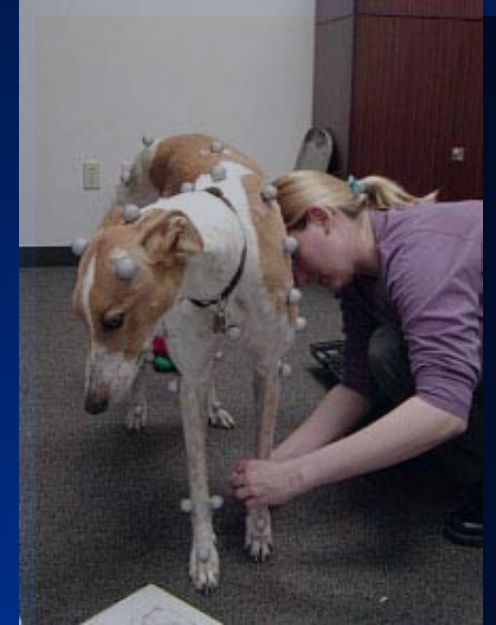
My Bio

- Have always lived in Columbus, OH.
- B.A. in Photography, minor in Zoology from OSU, June 1993
- Photography – studio, location and photomicroscopy, web pages, flash animations, posters, power point pres, journal illustrations of biomedical subject matter for teaching, research, publication.
- Entered Graduate School in 2001.
- Admiration for veterinary medicine, compassion for animals, and passion for creating visual art.

Acknowledgments

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- Mocap Studio Staff at ACCAD
 - Suba Varadarajan, Brian Windsor, Fran Kalal, Hussain Frosh, Ryan English, Vita Berezina-Blackburn, and other students
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- Chris Caprette: for his help with the dogs during capture and video taping, his ideas, and his love
- Departments that provided me with Graduate Associateships:
 - Industrial, Interior, and Visual Comm. Design
 - Radiology
- TELR for a Courseware Development Grant –Susan Metros and Steve Acker
- All the faculty, instructors, and staff at ACCAD
- The People who encouraged me, inspired me, and gave me references before I entered

The Stars of the Show



What I did

1. Created an interactive multimedia learning module on Canine Lameness using optical motion capture, video, and Flash web interface.
2. Created a short quiz with video and motion capture animation to see if one was better than the other for helping students identify lameness in dogs
3. Created a Survey of various visual media to test student preference

Background

- Need in VetMed: Lameness is a common problem in Vetmed. Difficult to identify lame leg/s.
 - A preliminary search in 2002 of Oscar, Ohio Link, CIC, and World CAT revealed only one VHS tape on evaluating lameness in dogs. Not available for check out.
- Need in VC: Exploration of new way to combine mocap, video, and Flash web design to create educational multimedia. Taking tech used for research or entertainment and creating something educational with it. Flash Player is ubiquitous on Mac and Win. Readily available to the student.
- No evidence that anyone has created a mocap / video multimedia learning tool on canine lameness. Software to create multimedia reports
 - “Motion Toolbox” – Humans only.
 - “Polygon” by Vicon Peak – Owner can freely disperse the PolygonViewer
- Preliminary Questionnaire in Musculoskeletal class

Early Questionnaire

- The needs / wants, qualities of the user group were surveyed in a questionnaire presented to the Winter 2002 Veterinary Musculoskeletal class.
- At that time, the overall response to the idea of having a new multimedia tool with motion capture was positive. In general, the students wanted more multimedia they could study from outside of class.

Early Questionnaire

- Multimedia they expressed interest in having:
 - Demonstration of Ortolani, Barden, Barlow, Cranial Drawer, & patellar stability tests
 - 3-D virtual anatomy combined with radiographs, anat. Of pelvis esp., **virtual knee**, origins & insertions of muscles, normal ranges of motion
 - fracture types & fixation, pins, screws, casts
 - reciprocal apparatus of the horse
 - **types of lameness**
 - effects of dif. Muscle groups on gait
 - effects of nerve damage
 - virtual surgery (arthrodesis & arthroscopy)
 - All of it! Immunology, gi functions, cardiac disorders, urinology, oncology, etc.

Early Questionnaire

- Do you think 3-D modeling of joints and motion capture of gait in lame dogs would help you visualize orthopedic problems in dogs?
 - Yes. Many wanted this for the horse. One mentioned ability to slow down the movement, another mentioned including healthy dogs for comparison, another wanted neurological mocap as well, another wanted video just as much or more, one wanted 3-D model running through space that could be stopped and started at will and rotated about in every direction – did not like sequences of still images for the gaits of horses.

Early Questionnaire

- What media would you like added to the class in addition to the 3-d and animation?
 - Many listed Video, physical models and web & CD content at the top of their list over books and white papers.
- 41/46 used Windows, 3 Mac, 2 had no computer at home
- 38/46 accessing supplemental web based class content at home
 - Most had dial-up modems (56k, 2 had 28.8k), 7 had broadband
- 38 comfortable using a computer to study
- Majority comfortable using computer for 1-2 hours.
- 36 print stuff off the computer to study from at length
- Access to at home: 31 had CD player, 25 had DVD player, all 46 had access to VHS player.

The Learning Module Review

- [Link to the Canine Lameness Learning Module](#)

Methods / The Technology

“Design is like Ditch Digging” – Paul Rand



What I had.

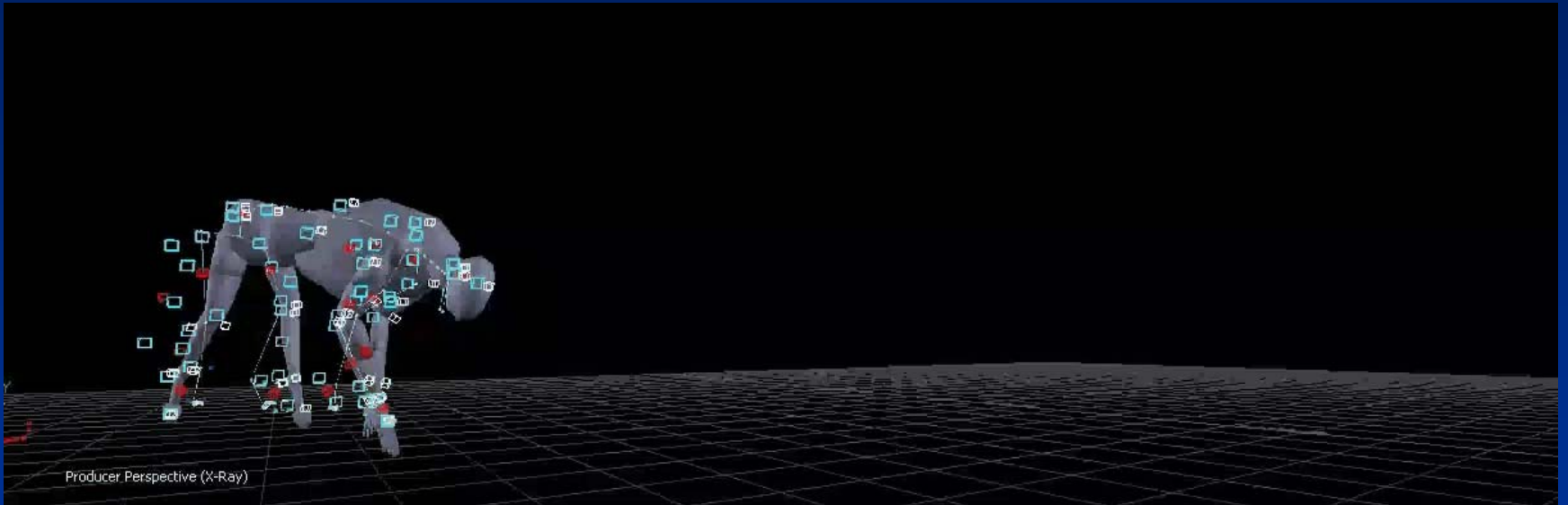


What I needed.

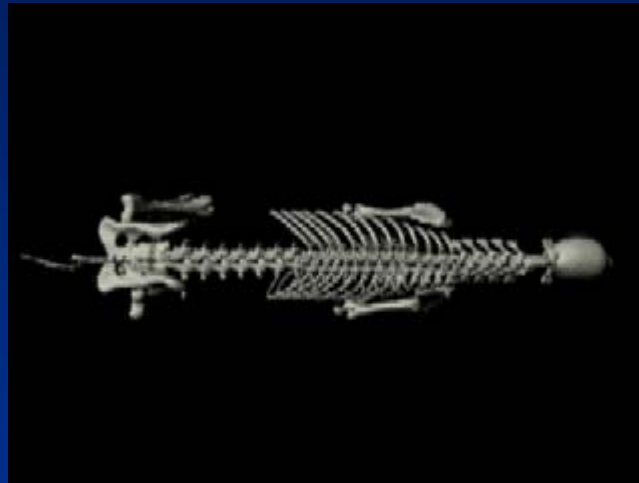
My Chunks of Granite

1. Trouble getting the optical motion capture markers to stay on the dogs.
2. Occlusion of reflected light from their markers.
3. Gaps in the data. Hand key-framing in Motion Builder and even Maya.
4. Swapping on ankles, pastern/wrists, sacrum and top of tail, the two markers on the front and side of the stifle (knee).
5. MotionBuilder 5.5 could not make a quadruped animation skeleton follow the dog marker data with accuracy. The technical support simply told me that I was trying to do something with the software that it wasn't made to do. [See Movie](#).
6. Not enough spine markers. [3-D skeleton bind issue](#).

MB 5.5 Best Attempt



3-D Bone Model Bind

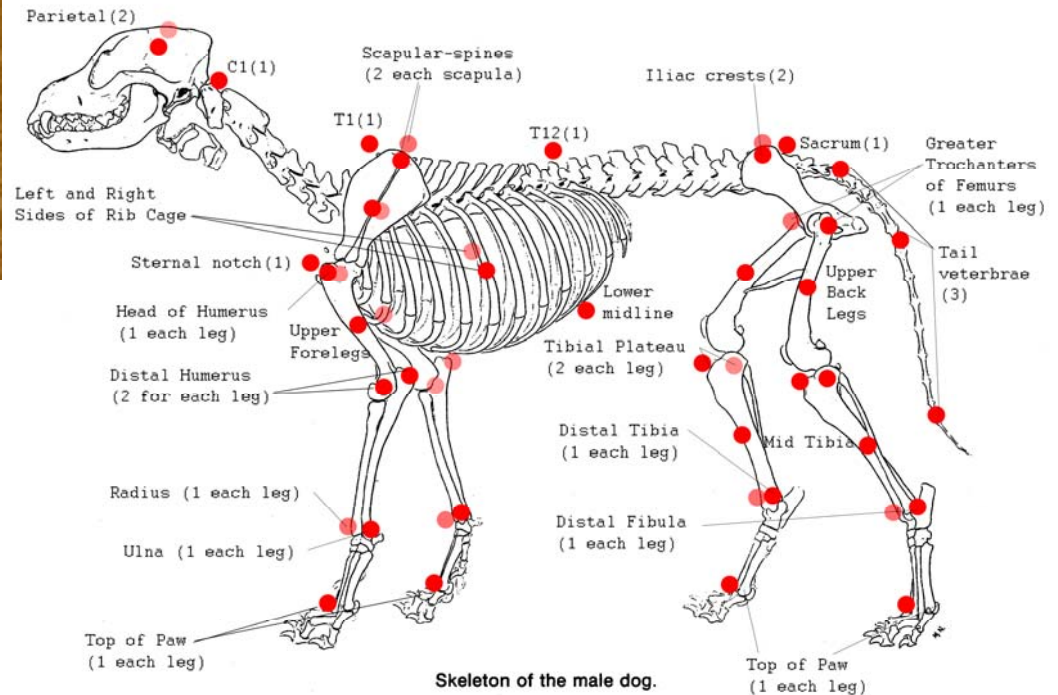


[Link to Side View of 3-D Bone Model](#)

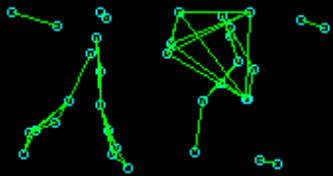
Process

1. Vicon Workstation
 - Capture, Labeling Markers, Fixing swaps, cutting spikes, deleting ghost markers, filling 10 frame or less gaps
2. Motion Builder 5.5
 - Filling large gaps (included hand keyframing), filtering data to smooth the jitter, exported as FBX
3. Maya 5
 - Building Mocap Animation Skeleton
 - Building and binding a 3-D model
 - Rigging / Constraining the anim skeleton to the marker data
 - Hand keyframing
 - Setting up cameras, lights, textures
 - Rendering images
4. Adobe Premiere 6 and Premiere Pro
 - Importing targa files, editing video (transitions), looping, slowing down
 - Exported as .mov
5. Sorenson Squeeze
 - Compressed the movie files and converted them to .flv
6. Macromedia Flash
 - Built final interface for student learning module
7. Macromedia Dreamweaver
 - Built html files that made up the survey and quiz

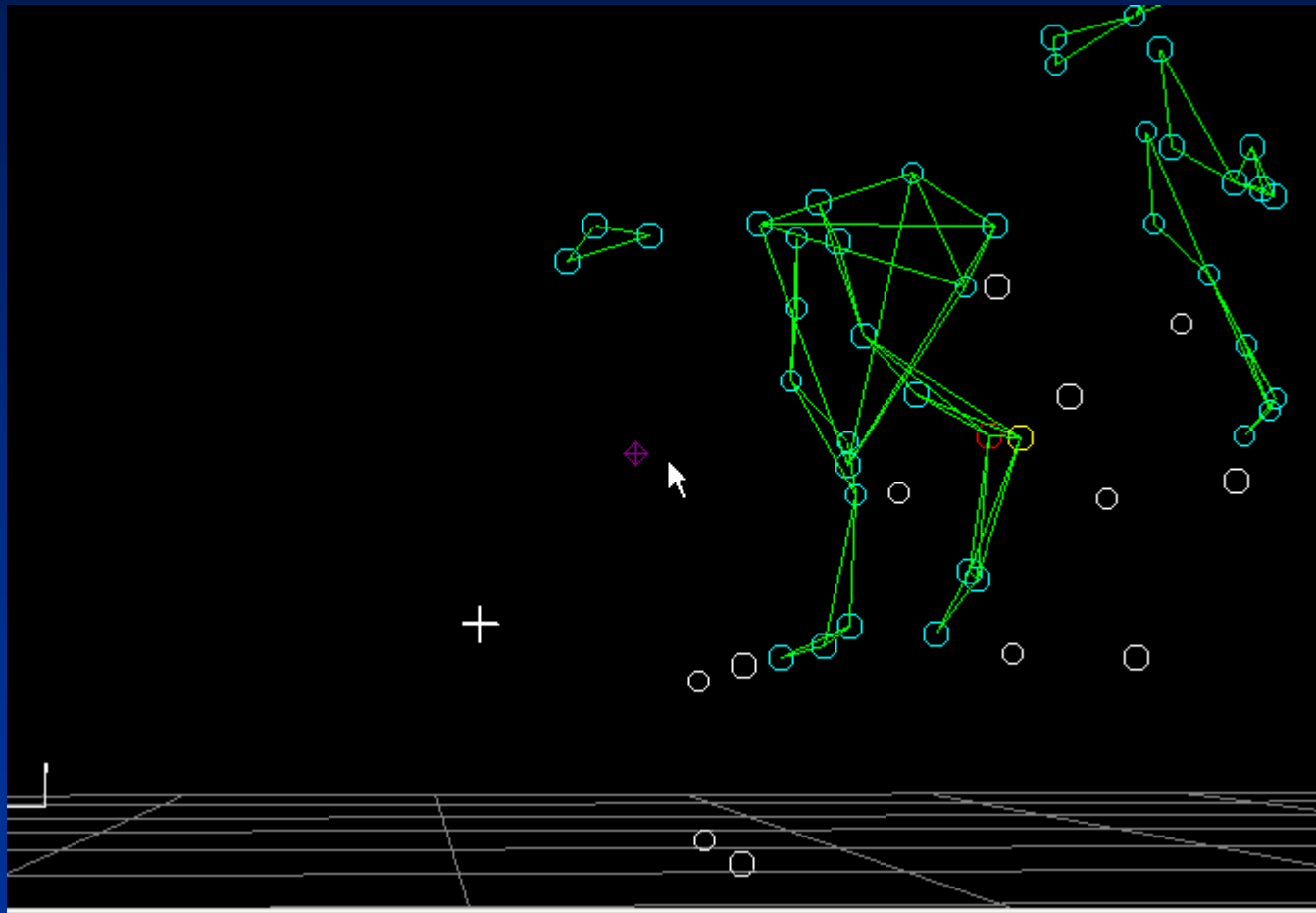
The Lycra Suit



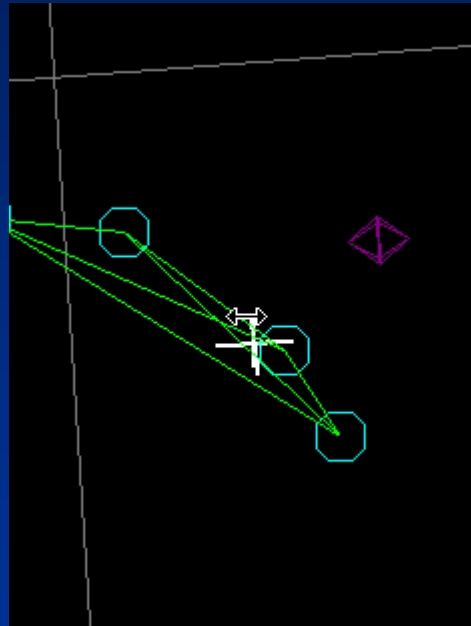
Gaps



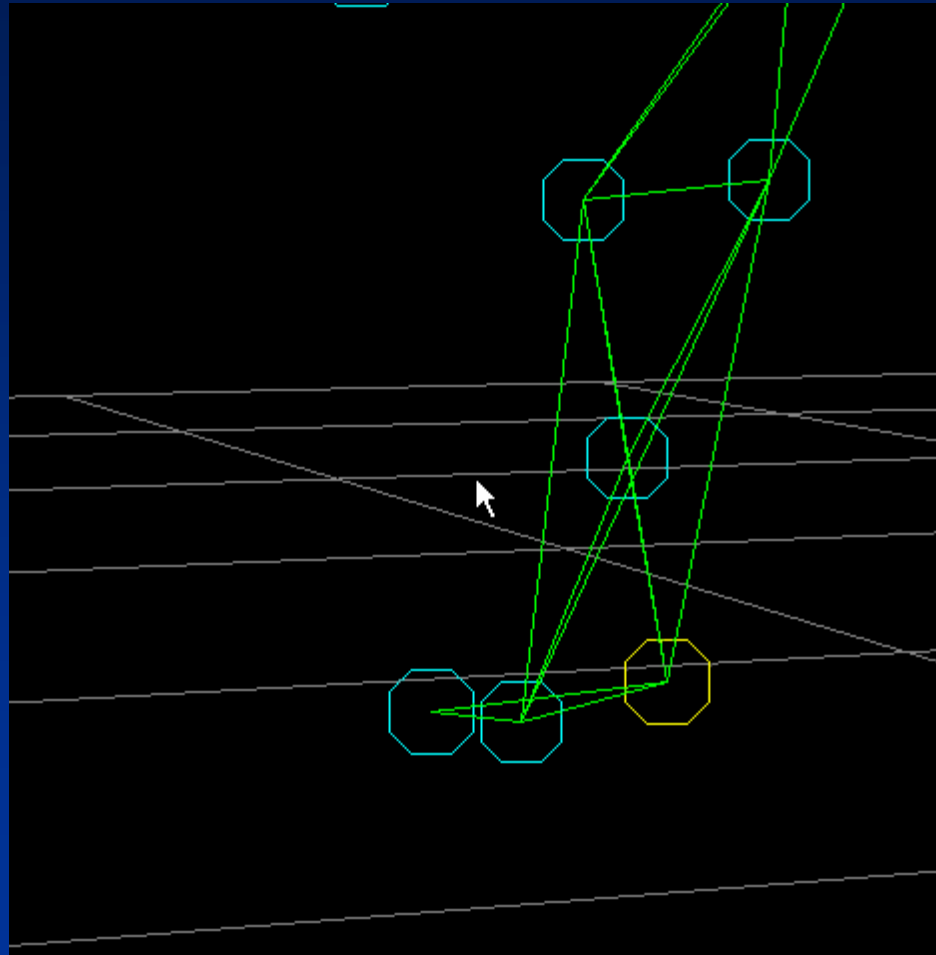
Swapping



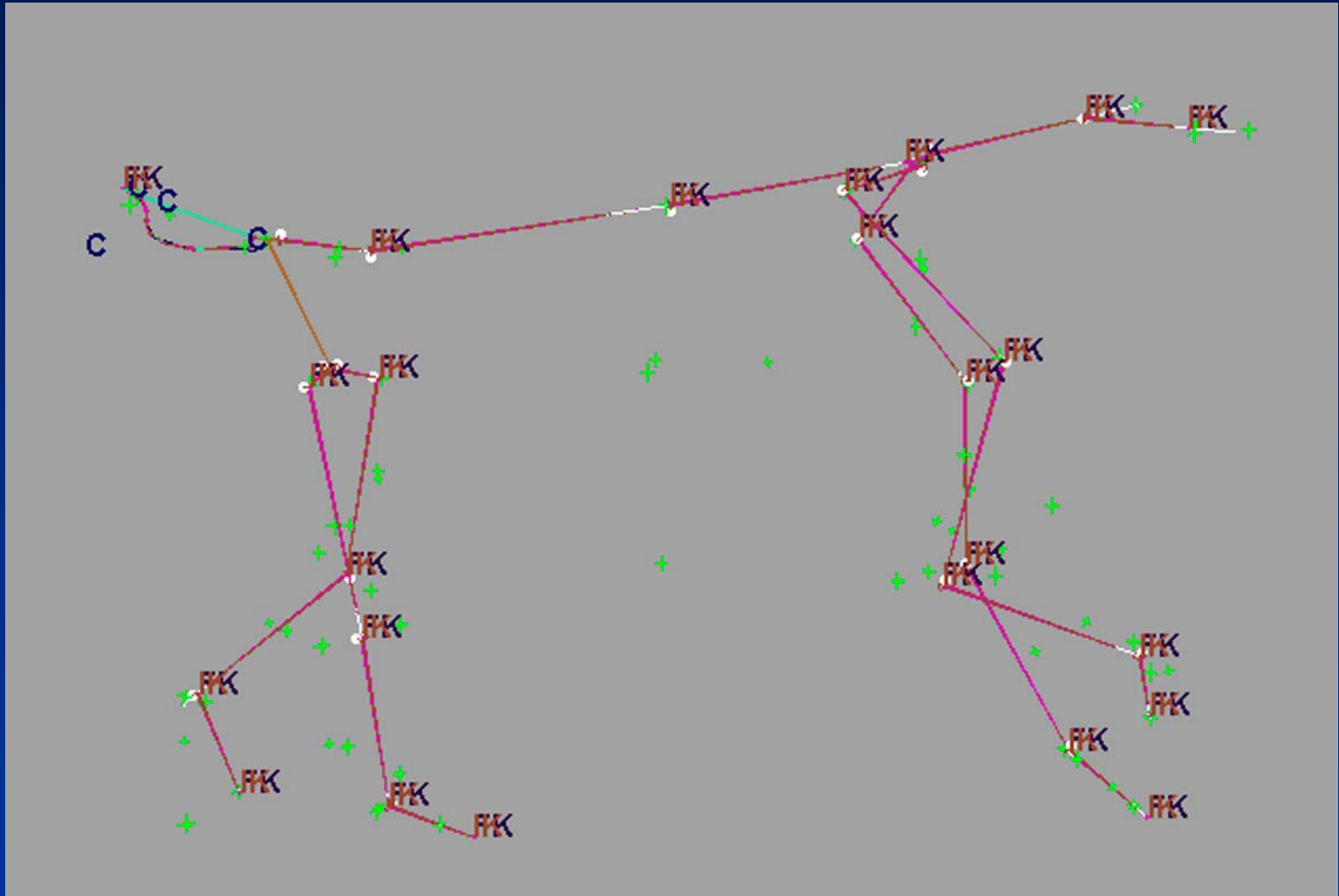
Ghost Markers



Spike



Maya Animation Skeleton



Quiz Results

- 14 out of 14 participants took the quiz.

Quiz Format

- Question was to identify the lame leg or legs
- Possible Answers
 - None. Healthy Gait
 - Right Hind Leg
 - Left Hind Leg
 - Both Hind Legs
 - Bilateral, Right Hind Worse
 - Bilateral, Left Hind Worse

[Link to the Quiz Questions](#)

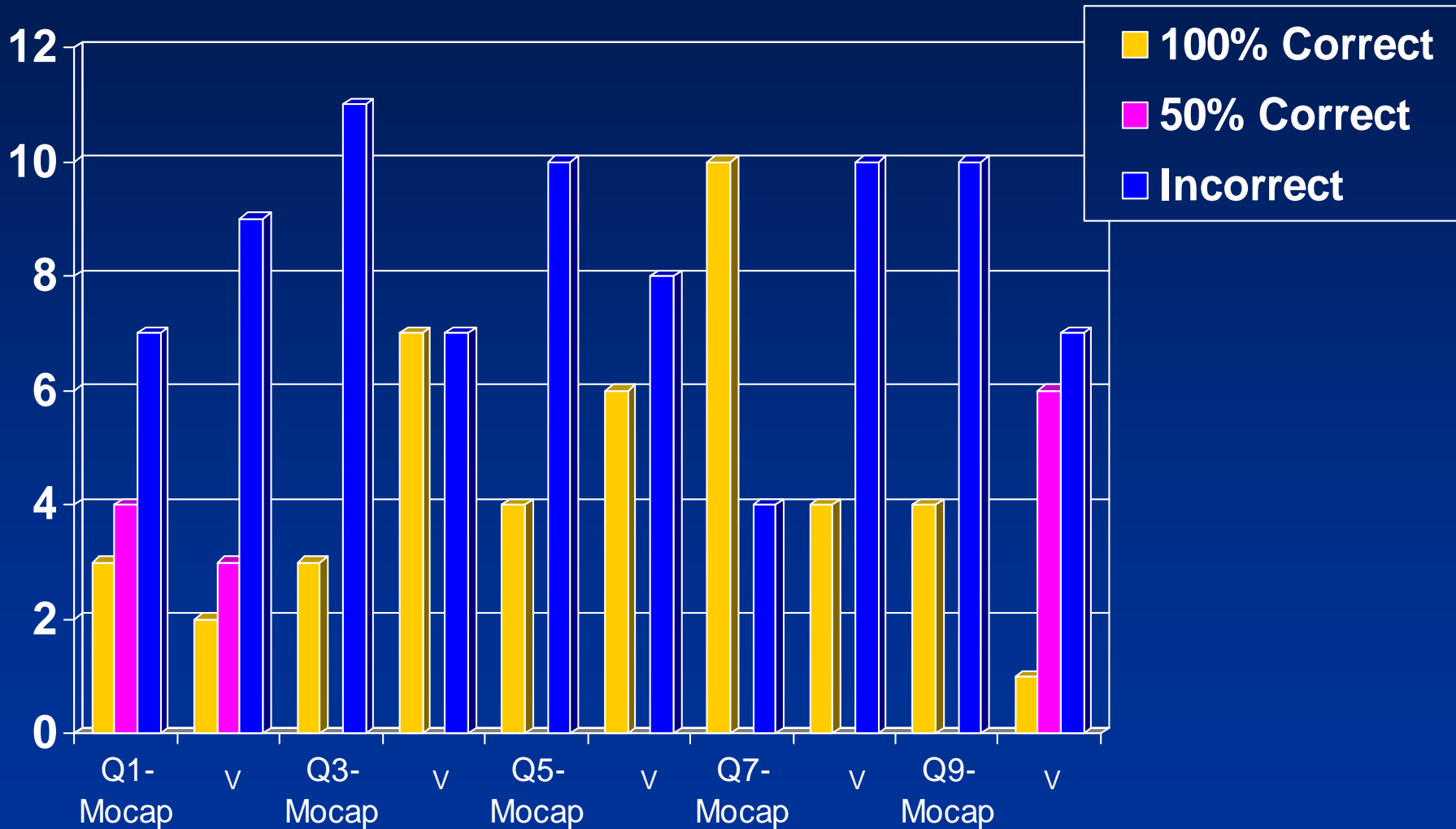
Quiz on Identifying the Lamé Leg/s in the Dogs: Tally of Answers and Values Given to Answers

	Question 1/A - Mocap	Question 2/B - Video	Question 3/C - Mocap	Question 4/D - Video	Question 5/E - Mocap
None. Healthy Gait	(0% or Incorrect) 1		(100% Correct) 3		(0% or Incorrect) 3
Right Hind Leg	(0% or Incorrect) 4	(50% Correct) 3	(0% or Incorrect) 2	(100% Correct) 7	(0% or Incorrect) 2
Left Hind Leg	(50% Correct) 3	(0% or Incorrect) 6	(0% or Incorrect) 7	(0% or Incorrect) 1	(100% Correct) 4
Both Hind Legs	(50% Correct) 1			(0% or Incorrect) 3	(0% or Incorrect) 3
Bilateral, Right Hind Worse	(0% or Incorrect) 2	(100% Correct) 2	(0% or Incorrect) 1	(0% or Incorrect) 3	(0% or Incorrect) 1
Bilateral, Left Hind Worse	(100% Correct) 3	(0% or Incorrect) 3	(0% or Incorrect) 1		(0% or Incorrect) 1

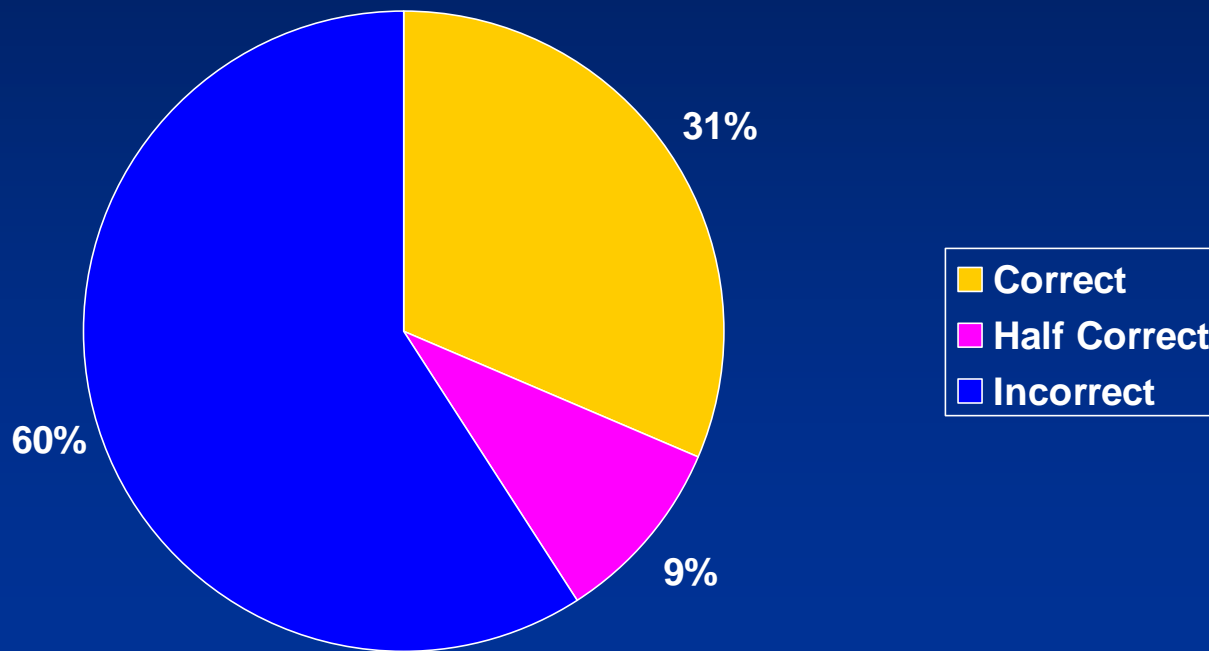
Quiz on Identifying the Lamé Leg/s in the Dogs: Tally of Answers and Values Given to Answers

	Question 6/F - Video	Question 7/G - Mocap	Question 8/H - Video	Question 9/I - Mocap	Question 10/J - Video
None. Healthy Gait	(0% or Incorrect) 3	(0% or Incorrect) 1	(100% Correct) 4	(100% Correct) 4	(0% or Incorrect) 1
Right Hind Leg		(100% Correct) 10	(0% or Incorrect) 4	(0% or Incorrect) 5	(0% or Incorrect) 1
Left Hind Leg	(100% Correct) 6	(0% or Incorrect) 3	(0% or Incorrect) 1	(0% or Incorrect) 2	(50% Correct) 2
Both Hind Legs	(0% or Incorrect) 1		(0% or Incorrect) 1	(0% or Incorrect) 2	(50% Correct) 4
Bilateral, Right Hind Worse	(0% or Incorrect) 1		(0% or Incorrect) 3		(0% or Incorrect) 5
Bilateral, Left Hind Worse	(0% or Incorrect) 3		(0% or Incorrect) 1	(0% or Incorrect) 1	(100% Correct) 1

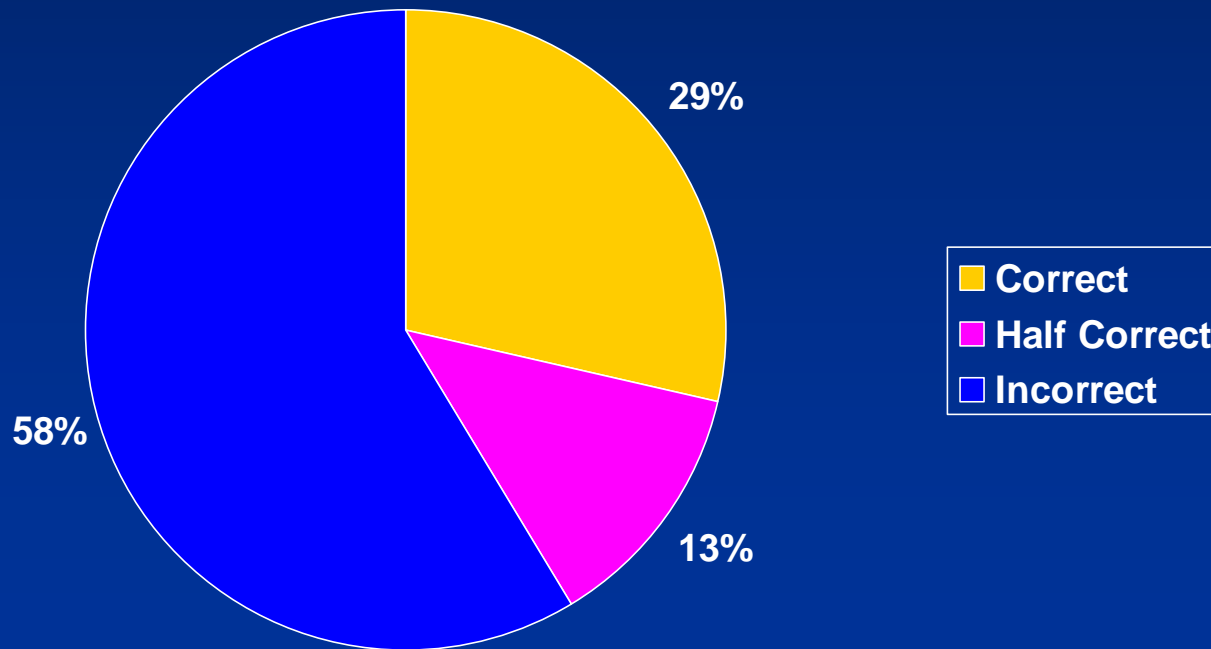
Quiz Answers - # Correct



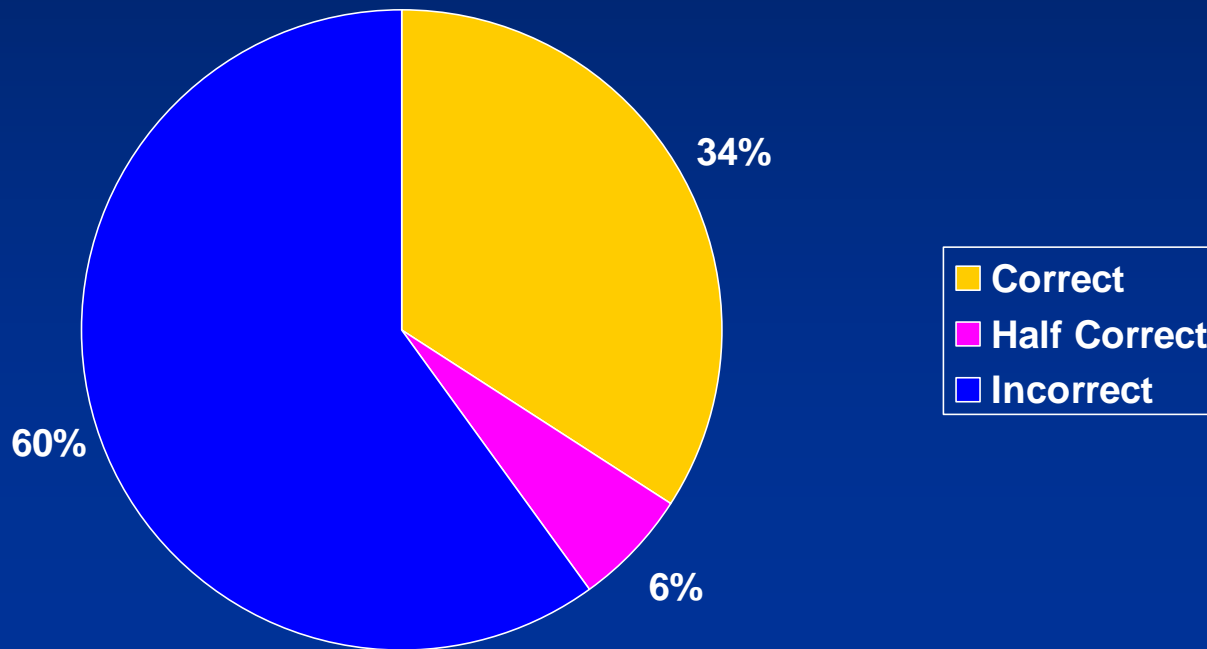
Percentages of Correct, Half Correct, and Incorrect Answers in all (140) of the Quiz Questions



Percentages of Correct, Half Correct, and Incorrect Answers in all (70) of the Video Quiz Questions



Percentages of Correct, Half Correct, and Incorrect Answers in all (70) of the Mocap Quiz Questions



The Survey

1. General Questions about the Canine Lameness Learning Module
2. Usability (Ease of Use) Questions
3. Visual Preference
4. Matching

Survey - Qualitative Questions

1. If you took the Canine Lameness Learning Module, did you find the video or motion capture animation more helpful in regards to identifying a lame leg? Or did you prefer to have both to study from?

(Participant 1) Both, but the video was more helpful because that is what I am used to.

(Participant 2) I prefer both. I liked looking at the motion capture first to figure out exactly where the legs are going then viewing the video.

(Participant 3) Both.

(Participant 4) Both.

(Participant 5) motion capture more helpful

(Participant 6) I liked having both – the motion capture to get the initial idea, then the video to check with

(Participant 7) video.

(Participant 8) I found the video more helpful simply because it was hard to get use to the capture animation. With more exposure to capture animation, I'm sure it would be just as helpful as the video.

(Participant 9) Video, though occasionally the motion capture helped to clarify.

(Participant 10) Motion capture better overall, but like to have both for some things (see below).

8-Both

4-Video

2-Mocap

Survey - Qualitative Questions

1. If you took the Canine Lameness Learning Module, did you find the video or motion capture animation more helpful in regards to identifying a lame leg? Or did you prefer to have both to study from?

(Participant 11) Video

(Participant 12) No results.

(Participant 13) Both. It was best to be able to compare.

(Participant 14) I thought they were both very helpful. It's a great idea! Next we need a horse one.

Survey - Qualitative Questions

2. What did you find to be the advantages and disadvantages of each medium: video and motion capture animation? Please explain:

(Participant 1) Motion Capture was nice to **define/highlight individual legs** video was nice to not have all of the color interference as you are trying to follow a leg

(Participant 2) I really liked the **different positions the motion capture can give**. Also, it **clears out all distractions** so you can focus on the points you want. The video shows an actual dog, which is what you will be **observing in practice**.

(Participant 3) I thought it was helpful to slow down the animation and watch it frame by frame. In the video, it was easier to pick up pauses in the gait.

(Participant 4) **I found the ability to isolate a joint most helpful in the motion capture to be able to compare degrees of flexion**. I then liked to follow that up with the **video since that is what I will have to do in life**.

(Participant 5) motion capture helped to visualize each joint individually

(Participant 6) video is more realistic, but motion capture is more helpful as a novice.

(Participant 7) video shows the whole dog moving, capture animation is more controlled, and can speed up slow down more precisely

Survey - Qualitative Questions

2. What did you find to be the advantages and disadvantages of each medium: video and motion capture animation? Please explain:

(Participant 8) Advantage: You are able to become familiar with many kinds of lameness without actually seeing that many patients. Video/Capture animation allows you to **slow the gait down and analyzed the footfalls**. I can't think of any disadvantages. I feel that this is another learning media.

(Participant 9) Learning from **video is more applicable to a real life** situation. Motion capture was very good for clarifying things but it took me a little longer to pick out the lameness on this than on video.

(Participant 10) **Video better for toe touching, motion capture better for head bob, range of motion, and extra views.**

(Participant 11) Motion capture eliminates distractions seen in the video, such as background objects. It is harder for me to identify the lame leg in motion capture. My eyes get confused easier as to which is the left and right legs and I find it hard to follow the motion because the animated figure is **"floating"** in space.

(Participant 12) No results.

(Participant 13) Video is more realistic. There is less distraction with the motion capture.

Survey - Qualitative Questions

2. What did you find to be the advantages and disadvantages of each medium: video and motion capture animation? Please explain:

(Participant 14) Motion picture – I thought the similarities in the blue colors made it difficult to distinguish which leg was which. Try red, pink, blue, and then a deeper green or purple. Video – diad- for the steps outside video – I **would have liked to have a normal dog running side by side for comparison**. You may be able to accomplish this by stationing one person at the top of the stairs and one at the bottom. Call the dogs back and forth and reward them with a tiny tiny bit of meat, cheese, etc. whenever they reach each person. Sometimes when I went back for comparison, the size difference between dogs would throw me off a little. Also **crooked walking and biting leash** were distracting. Try gentle leaders to cut down on this. Overall I thought it was an excellent teaching tool, and I really liked being able to look at it frame by frame. It gave me the idea that I could video dogs in practice and then look frame by frame also.

Survey - Qualitative Questions

3. Which perspective/s did you find most helpful in identifying a lame hind leg?
The perspectives were: side, overhead, frontal and posterior.

- (Participant 1) Side
- (Participant 2) Side & Posterior
- (Participant 3) Side & Posterior
- (Participant 4) Side
- (Participant 5) Side
- (Participant 6) Side
- (Participant 7) Side & Overhead
- (Participant 8) Side & Posterior
- (Participant 9) Side & Frontal
- (Participant 10) Side & Posterior
- (Participant 11) Side & Frontal
- (Participant 12) No results.
- (Participant 13) Side.
- (Participant 14) Side & Posterior

13 - Side

5 - Posterior

2 - Frontal

1 - Overhead

Survey - Qualitative Questions

4. You can use the space below for any comments about the perspectives:

(Participant 1) Great job, this is a great learning tool! - **Positive**

(Participant 2) No answer.

(Participant 3) No answer.

(Participant 4) No answer.

(Participant 5) this was very useful and the motion capture would be good for teaching in a classroom setting - **Positive**

(Participant 6) No answer.

(Participant 7) No answer.

(Participant 8) No answer.

(Participant 9) No answer.

(Participant 10) No answer.

(Participant 11) I think overhead perspective is helpful in this program, but not a common perspective obtained in clinical practice. - **Neutral**

(Participant 12) No results.

(Participant 13) No answer.

(Participant 14) It's difficult to get a good overview of a large dog in real life. - **?**

Usability of Learning Module

- 13 out of the 14 responded

Questions about the Usability of the Canine Lameness Learning Module

How easy was it to become familiar with the Canine Lameness Learning Module?

Very Easy	Easy	Somewhat Easy	Difficult	Very Difficult
5	6	2		

The Canine Lameness Learning Module always did what I expected it to.

True	False			
13				

I enjoyed using the Canine Lameness Learning Module.

True	False			
13				

I understood what each selection did simply by reading the label on the tabs and buttons.

True	False			
13				

The instructions provided with the Canine Lameness Learning Module were easy to understand.

True	False			
13				

The information presented in the Canine Lameness Learning Module was clear and easy to understand.

Always	Most of the time	Half of the time	Less than half of the time	Never
6	7			

Comments: Please use the box below to elaborate on any of the above answers or make any comments about the Canine Lameness Learning Module:

- (Participant #3) I thought this CD was a very **good idea**. I've always found judging lameness to very difficult. I'm going to save it and use it in clinics.
- (Participant #4) Something that might decrease the learning curve in the very beginning for the student in terms of translating a 3D image to 2 is to color code the limbs the same as one would place **EKG leads** (White=R fore, black = L fore, etc.)
- (Participant #5) I think the motion capture would be **good to use** in the 2nd year musculoskeletal course.
- (Participant #11) The presentation was helpful and easy to understand. However, on my computer screen, the movie screen and the manipulation buttons for the movie (play, stop, etc) **did not fit on the same screen** – I found it frustrating to have to scroll up and down to change the video speed, etc.
- (Participant #13) When the dog with hip dysplasia was not trotting, I became a bit confused until I read the entire text.
- (Participant #14) **Need more commentary on how to distinguish between just one lame back leg or both back legs lame. Or more videos of one versus two affected legs.**

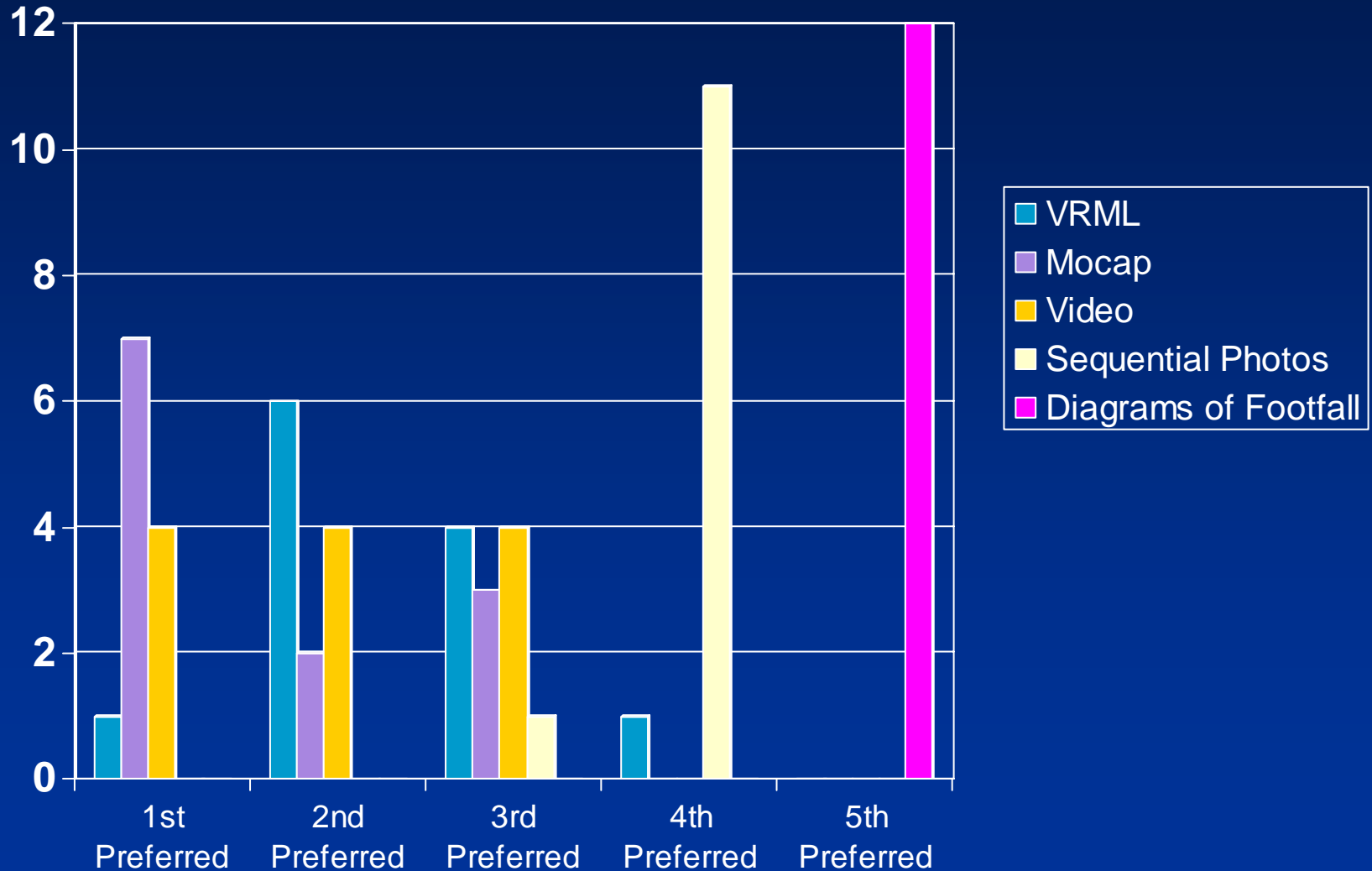
Visual Preference Results

- 12 out of 14 responded
- [Link to the Survey of Visual Preference](#)

Answers to the survey of visual preference for media used to teach about gait in canines.

	VRML	Mocap	Video	Sequential Photographs	Footfall Patterns
1st Most Preferred	1	7	4		
2nd Preferred	6	2	4		
3rd Preferred	4	3	4	1	
4th Preferred	1			11	
5th Preferred					12

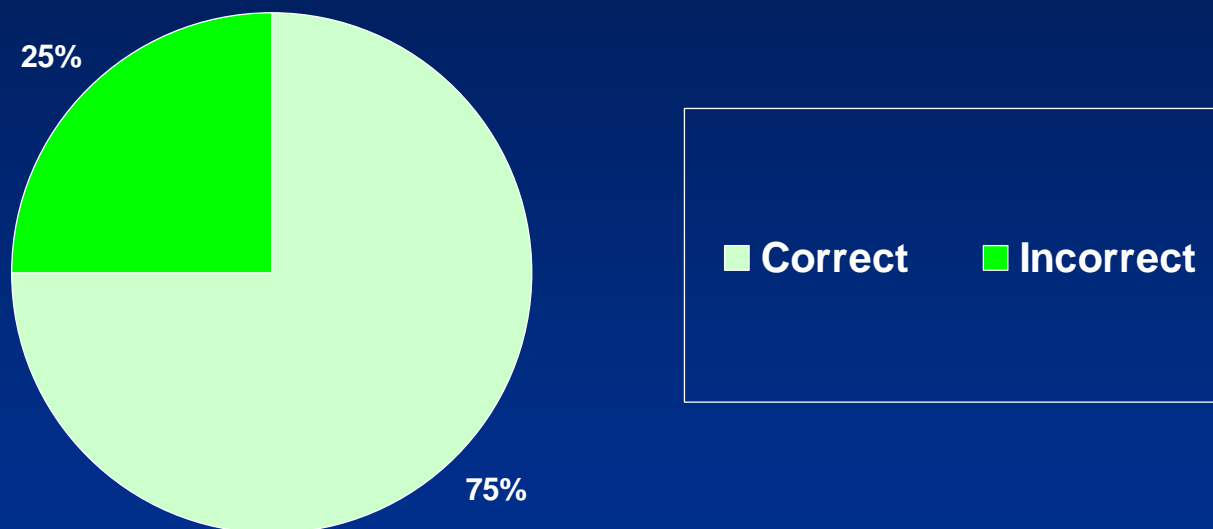
Student Visual Preference



Matching Results

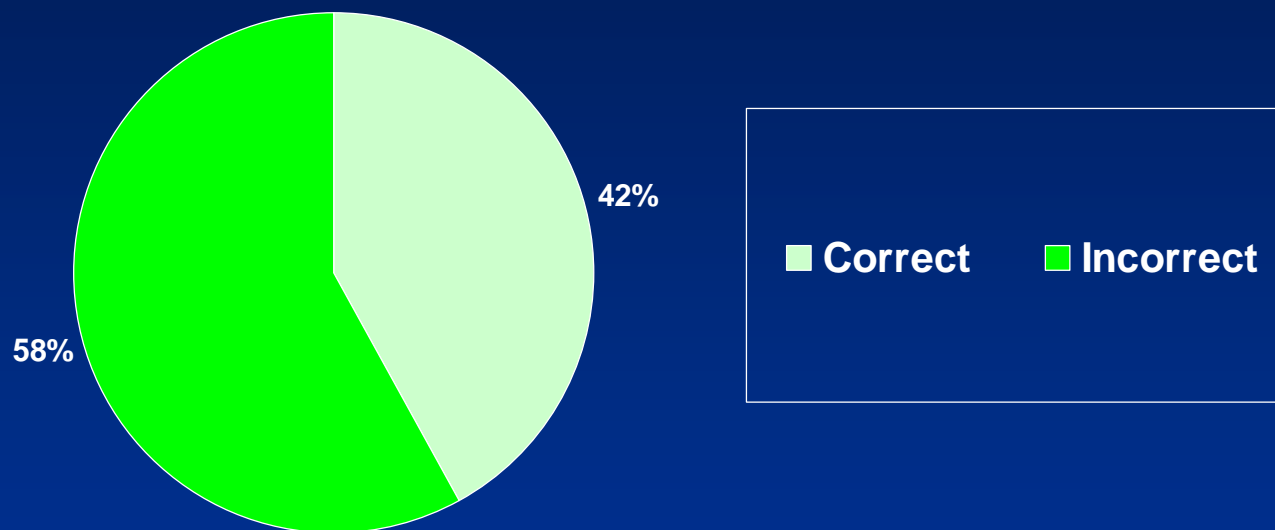
- 12 out of 14 participated in matching

Given Video, Pick the Matching Mocap Animation



[Link to Matching. Given Video, pick the motion capture representation of the same dog.](#)

Given Mocap, Pick the Matching Video



[Link to Matching. Given Mocap, pick the video representation of the same dog.](#)

Conclusion

- Mocap not a replacement for other media, especially video. Just another means of conveying the information.
- In general, the response to the mocap animation and VRML created from the mocap was positive. Worthwhile endeavor.

Benefits

- **For V.C. Design** – explored a new means to create visuals for educational multimedia. Showed how a technology (i.e. mocap) that is primarily used for video games and character animation in Hollywood movies (entertainment) and in research, can be used in a web based flash presentation, for education, taken directly to the student for review at their leisure.
 - It's an example of how many design technologies and methods (specifically, motion capture, 3-D modeling, animation, video, and web design) can be tied together to produce one product.
- **For Veterinary Medical Education** – provided students with educational multimedia that will enhance their learning experience. E.g. it will improve students knowledge about canine lameness. Offers another medium for learning about gait and it is portable. They can insert the CD into any computer.
- **Personal Gain** – broad range of knowledge and skills.

Expanding

- Could do the same thing but with BodyBuilder or Body Language scripting. More time to take measurements of the dogs with markers on before the capture.
- I would like to do a 3-D dog anatomy in a VRML or Shockwave interface – like a program called the glass horse.
- I would like to do a kinesiology lesson with an animated 3-D dog, showing what major muscle groups are involved in different gaits.
- The mocap could be used to create a human gait analysis multimedia program for physical therapy students and medical students (orthopedics and neurology).
- One student wanted a mocap learning module on horse gait analysis / lameness next.
- Potential customers of another multimedia CD-ROM would be publishers of veterinary medicine and human medicine. Ultimate consumer would be the student.

What I would do differently

- More markers along the dogs' spine, especially thoracic and lumbar regions.
- Try smaller marker size and closer lights.
- Would be nice to shave the dogs and adhere markers directly on skin.
- Would be nice to have dogs trained to go across the mocap space without a lead – less occlusion.
- I would have taught myself how to use a program / Scripting Language called Body Builder in order to get measurements from the mocap data, like range of motion on a joint. This would have required taking detailed measurements on the dogs prior to the captures. More time consuming.



Heather Caprette's marker placement for a dog.



Vicon Peak's marker placement for a dog.

