Techniques Outline

* What kind of lab do I want to have?
  + With my passion for sports, I would like to have a lab that is able to study the sports biomechanics in a variety of methods.
    - My priority would be for kinematic analysis using MOTION CAPTURE to gain insights on how we move in various sports and conditions. So the hardware needed has to be flexible and likely tuned to the most explosive sport as a priority (i.e a baseball swing capable cameras that can be used for gait analysis).
      * Measurements gained:
        + Segment Velocity
        + Jump Distance
        + Jump Height
        + Power
        + Segment Angles
        + Joint Angles
    - Another important factor would be force plates that could be incorporated to gain insights on the kinetics side of the movements. The hardware again must be geared towards more explosive movements and force outputs since the athletic population have a higher output than majority of the population
      * Measurements gained from the force plate data:
        + Torque Calculations during gait
        + Force indicators for potential risk of injuries
        + Inputs for musculoskeletal models
        + Timing of applied forces
        + Can be used as model inputs
    - Outside of mechanics on how the body is moving, to me the timing that the muscle activates is just as important as the force being produced. For example, someone can have the hamstring strength that wouldn’t pose a risk but when performing safe jump landing mechanics, their hamstrings may not fire on time/in sync with the motion which still places excessive force on the ACL. Again, I think it is just as important to know the when versus strength
      * Measurements/Insights gained from EMG Data:
        + Fatigue effects
        + Estimate of muscle force production
        + Time course of muscle activation
        + Coordination patterns between muscles
        + Useful in modeling and forward dynamic analyses in order to predict muscle force
    - Besides gaining insight on performance, I also have an interest towards injury prevention and believe that ultrasound could become a relatively quick, affordable way to predict injuries/gain internal insight on the muscular conditions of people that could lead to injury (for example, hamstring fibers are torn up when looking at the hamstring post-training session)
      * Measurements gained from Ultrasound:
        + Insight on material properties
        + Fiber lengths
        + Pennation Angle
        + Cross sectional area of the muscle
        + Most importantly, the material stiffness of the muscle
  + Then of course, with all of the hardware, there is the software that comes with it to analyze the data.
* What hardware would I need?
  + A computer with a large RAM and storage capacity to handle processing the data being relayed to it and to handle these large sized programs. Must be capable of storing large datasets and files of data, especially with an increase in digitization (usually by an increase in trial length OR the number of markers)
    - Also a TV to be able to display our collections, findings, real-time feedback, etc.
  + For Motion Capture I would need at least 3 cameras but since I went to look at athletes and explosive, ballistic movements I need the hardware to be able to accurately describe it. Hence I will need:
    - Cameras:
      * 10 cameras that have variable frames per second and would want to have cameras with the highest FPS before resolution drops
      * At least 2 cameras that can shoot high definition video at a fairly high frame rate, although three seems ideal to me in order to assess with gap filling parts
    - Marker Sets:
      * Enough markers to be able to adjust based on the movement’s goal. Needs to be able to handle as much as the point cluster technique and something as minimal as the Helen-Hates marker setup
      * Need enough markers for replacements too, things happen to markers
    - Calibration System:
      * All of the calibrations that are needed for the cameras to orient themselves, typically comes with the camera brand chosen
  + For force plates:
    - I would ideally like at least two force plates next to each other, that way I have the ability to perform measurements with two legs on a plate or a leg on each plate to see how the forces are changing with both
      * Having the force plates contain 4 tri-axial transducers, it only makes sense to me considering we are constantly working within 3 planes of motion
    - Then for baseball specifically, I would like a force plate that’s built into a mound-like object. Majority of sports are spent on a flat surface but baseball specifically has a mound for pitchers who are always performing on the field.
      * What could be more useful than understanding push off, center of pression, change in weight distribution, etc. for pitching than with a collection most similar to pitching
    - We also need to process the data being collected:
      * An amplifier that has high enough gains to handle a variety of movements. Need to be able to shift the gains based on whatever movement we are using
        + Voltages for force plates are low so we need to amplify the signal
        + Higher gain for higher force/explosive movement
      * We also would need an analog-digital board (A-D board) that is able to take the analog data from the force plates and turn it into digital data for the computer to be able to read it.
        + Could always make my own but since I have a blank check I’ll just get a nice big one that can handle as many inputs as possible
  + For EMG:
    - I prefer a non-invasive approach to getting a measure on the Electric Potential Difference of the muscles
      * The only hardware for this would be to buy the EMG surface electrodes
  + For Ultrasound:
    - A current ultrasound machine that is able to handle various forms, probes and manual adjustments to the collections.
      * Would need to buy at least two probes that are designed for Musculo-skeletal muscle, one for more superficial structures and one for deeper structures
      * The ultrasound also must have a shear wave elastography mode that shows the stiffness of the tissue
      * And of course a gel warmer, the patients would be much appreciative
* What software would I need?
  + For Motion Capture, Force Plate and EMG
    - A software that is our tracking manager that is able to handle the data from the motion capture system, the analog to digital data of the Force Plate and the analog to digital data of the EMG
    - The software also has to export the motion files as a C3D format to be able to perform calculations through independent analysis or through models
  + For ultrasound, calculations can typically taken from the ultrasound machine’s software
    - If we can’t, likely would use an open-source segmentation analysis software, edge-detection software, etc. to perform analysis on the images
  + To perform various analyses, it would be best to purchase a software that we can use for data analysis. Helps with speed and people not as in tune with programming
    - V3D is my preference since it is still very popular and it is what I am most familiar with. Understand that it is based off a static model and applies the necessary analysis
      * Inverse Kinematics, Inverse Dynamics, functional joint center calculations
    - I like its ability to create pipeline commands and reports for clear and easier analysis.
  + For independent analysis, I should also probably get Matlab since it still has a heavy following and can use Matlab for modeling purposes.
    - Can use their own preference of coding as well (Like R and Python)