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Research Experience Reflection

Prior to this summer research internship, I did not have any previous research experience. However, several factors influenced my interest in research. For several years, dating back to junior year of high school, I have desired to participate in research. Exploring the unknown, the potentials to discover new ideas and things, and the direct output of having a positive impact on somebody’s life were the initial primary attractive factors to research. Research in the field of sports medicine just more recently specifically captivated my interest due to my love and passion for sports and exercise. This field seemed, and continues to appear, like the perfect way to combine both my personal interests with my career goals and interests. The most important criteria I have for selecting my future career is that I love what I am doing, and to date, this is the best option I have discovered.

After not receiving a placement for the SURF Summer program, I was determined to find myself a summer research opportunity. I wanted any type of research I could find in order to see firsthand if it is actually something I could see myself doing for my future career path. The way I perceived the situation was that any experience was better than nothing. Moreover, if possible I wanted to start making connections, preferably with doctors and researchers in my areas of interest, as these will be very important in the upcoming years. As the result of various emails and a few personal meetings, I was offered an internship position in the Sports Medicine Department at Cincinnati Children’s Hospital Medical Center, working with Nate Bates, a graduate student in Dr. Tim Hewett’s lab. The project I was to be assigned initially did not seem very exciting; however, that could not have been a more inaccurate judgment. My task, in a nutshell, was to debug the problems encountered in a musculoskeletal modeling and simulation software being used to analyze subject motion.

In order to be able to attempt this, I had to teach myself how to use the program, OpenSim, as well as learn XML coding language that would be necessary to write and edit required files. OpenSim was developed at Stanford University as a free, downloadable program for musculoskeletal modeling. Additionally, I read a recent dissertation from a University of Louisville graduate student who did a similar, slightly comparable study using OpenSim to try and gain a better understanding of the capabilities and needs of the program itself. I also read other papers that utilized OpenSim for various motions, even though not all were extremely pertinent or relatable to this specific project. Because OpenSim is still a relatively unknown and not widely used program, there is not a large quantity of resources available.

OpenSim works in multiple steps to model subject motion, captured from the Human Performance Laboratory using 3-D Motion Capture systems. These steps include model scaling, Inverse Kinematics, Inverse Dynamics, Residual Reduction Algorithm (RRA), and Computed Muscle Control (CMC), and Results Analysis. Before I began working with the project, all of the files necessary to run each step had already been created. Additionally, a MATLAB (mathematical and engineering software) code had been written, so that once each individual step outputted acceptable results, the code would automate running the entire series of steps for every individual subject’s data, which is approximately 200.

Due to the nature of the project and its unfinished state, I cannot go in to great specific details of the project and overall study. When I took over the project, the results from RRA were unacceptable, producing residual error values, for forces and moments in the X, Y, and Z coordinate directions, in the thousands, when values less than 100 are desirable. Because of these large error results, CMC would not run completely. The computerized model would begin to explode at a time of approximately .1 seconds, and the whole process would fail by .17 seconds (the complete motion is .54 seconds). To start, RRA was the primary focus. In order to achieve the desirable RRA results, I made several changes to the input variables necessary for RRA, which include Actuator and Task files as well as minor selective options such as data filtering frequencies and time delays. Upon achieving manageable RRA errors, my focus turned to CMC, which uses data from all the previous steps as well as recorded ground reaction forces to compute muscle excitations that drive the computerized model through the desired motion. Progress for CMC was achieved in a similar manner to RRA, making minor adjustments to the various inputs based on each trial’s results. Although I have made large gains in progress with CMC, the current results are still not exactly what we are looking for. One of the largest obstacles to this step of the project is time. With slight variance due to a few variables, the time one trial of CMC takes to run ranges from three to five hours because for each hundredth of a second, the program is performing mathematical derivations. Thus, I am continuing to work with the program in hopes of seeing results closer to what we believe should be seen from the data. As a point of reference, when I spoke with a graduate student who used OpenSim to model squatting, he informed me that one trial for him took approximately four hours and overall it took him over four months to debug the CMC process completely.

In attempting to debug the program and find the root cause of the different reasons for failed results, I gained valuable experience analyzing results and analyzing the reasons various variables changed and were affected by different changes. This skill was not only useful in working with this specific project, but it will be applicable to every project and job I encounter in the future. Quality analysis can help save time rather than simply guessing and checking results. Although I do admit, at times, the changes I made to different pieces of the program were mere guesses in hopes that they produced a positive outcome. I only reverted to guessing and checking when all other options seemed to be exhausted without any or significant positive changes. Additionally, an extremely valuable skill I attained was patience. I have never been a very patient person; however, this project necessitated patience between trials, patience when positive results were not seen, and patience to persevere and keep trying new things without giving up. Finally, I furthered my independence in the manner that I was in charge of my own work and progress with this project. Nobody was sitting over my shoulder dictating what to do, how to do it, and when to do it by. If I had a question or an idea, Nate and others were available to assist in any way they could, but the project was uniquely my task. This was something I had not been previously exposed to.

Looking back, I am extremely grateful for Nate believing that I could make progress on this project rather than simply turning me away (as he has had several poor experiences with interns in the past). Not only have I learned how to use an extremely unique and valuable program that is relatively unknown, but I also learned an incredible amount about biodynamics of the knee. Since the motion I am modeling is a drop box jump, I focused all of my outside readings and learning of anatomy on the knee and to a lesser degree the whole leg. This was a very fitting topic, as quite often the material I was learning in my Biomechanics summer course directly corresponded to my project. It was very satisfying to finally start to see the application of classroom material in the practical field. Additionally, I was able to engage in many intellectual and subject specific conversations with doctors and therapists in the department because of the knowledge I had gained with the project and the summer class.

Moving forward, I would like to demonstrate the program and what it can do to various faculty members that could potentially benefit from the capabilities and possibilities it offers. I am planning on contacting the professor from my Biomechanics summer course to discuss this with him and see if he can offer any suggestions as to who this audience may include. At the current time, I cannot present any results because there are not any concrete final results worth sharing, yet. However, I believe, and hope, that I am very close to getting these. After the acceptable results are achieved, we will run the program for all subjects. These cumulative results will then be used to write several different articles. In my next research experience, I plan on getting more involved in other projects and studies in the department as time permits. Although the different doctors told me I could observe their work whenever I desired, I tended to be a little shy and not reach out as much as I could have. To peers who are looking to engage in research, I would tell them to take their own initiative. If you look hard enough and talk to the right people, there will be an opportunity somewhere for you. Do your research, learn about different studies, and be prepared to ask questions when you meet with a doctor or Primary Investigator. I quickly realized they like when students initiate contact and take interest in their work.

This experience has greatly furthered my interest in Sports Medicine and research. I really enjoyed the work I was doing this summer and even more enjoyed the different studies I observed, including pre- and post- summer musculoskeletal-specific individualized athletic training and concussion testing. The vast array of possibilities the field offers is extremely exciting and I look forward to see what more comes in the future.