Lacrosse Throw Modeling – Inexperienced Versus Experienced Players

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BME 599 – Modeling and Simulation of Human Movement

INTRODUCTION

One of the most basic and fundamental skills in the sport of lacrosse is the ability to throw the ball accurately and with a high velocity. This ensures a higher chance of scoring goals as well as keeping passes from being intercepted. Many factors affect accuracy and ball speed. The shape of the head, the way the head of the stick is strung, and hand position are but a few. Also, the shaft will affect ball speed by deflecting slightly as the throw is performed (Crisco).

To meet the timeframe of this project, the simplest model was used. To accomplish the simulation, many assumptions were made. A rigid shaft was used, which caused a decrease in velocity, but it would decrease for both throwing forms. Also, a typical lacrosse head was not used; a basic rectangular box of similar size and shape was substituted. An example lacrosse stick configuration can be seen in the Appendix – Figure 1.

This project report presents the development of a model that describes the difference in hand positioning between inexperienced and experienced lacrosse players and noting the effect of hand positioning on ball velocity.

METHODS

The model required for the simulation would need at least a full upper body with enough degrees of freedom to perform a throw. Initially, the aim of the project was to use the Arm26 (Appendix – Figure 2) example from the OpenSim 2.4.0 free download (Delp). This model contains only one arm, but provided a decent beginning. A full upper and lower body model created by Menegolo was found at www.simtk.org but it provided too difficult to manipulate because of the complexity of the model. The bodies would also require masses to perform forward dynamics, which the Menegolo model did not contain. Next, attempts were made to "scavenge" left arm geometry files from the Menegolo model into the Arm26 model to create a simple two-handed model. The ground reference frames of the two models are different and therefore yielded incompatible combinations of geometry files.

Many efforts to manipulate the left hand geometry files proved unsuccessful. Attempts at using Rapidform (INUS Technology, Inc. & Rapidform, Inc.) software to mirror the right arm to the left were successful in mirroring the ulna and radius, but the hand was translated roughly 0.5 meters down and 0.25 meters to the right from the model's perspective. The right hand was finally able to be mirrored using Paraview v3.14 (Kitware).

A rigid shaft with length of 76.2 cm and a box that was the basic dimensions of a typical lacrosse head was used as a representative lacrosse stick (Appendix – Figure 3.). The stick was attached to the model's hands by use of custom and weld joints in the model's .osim file.

The complete model consisted of an upper body torso with 14 degrees of freedom. The arms were separated into three parts: upper arm (humerus), forearm (ulna and radius), and hand bodies (Appendix – Figure 4). This allowed enough degrees of freedom for the model to perform a throw while minimizing the complexity of up to 40 extra degrees of freedom from the hands. For the inexperienced player form the hands were placed 52 cm apart, while the experienced player's hands were placed 14 cm apart. These values were chosen from their resemblance to observed distances. The difference in distances can be seen in the Appendix – Figure 5.

Once the model was completed, motion was added to simulate a lacrosse throw. Joint degrees were both measured (larger moving joints such as elbow flexion) and estimated (wrist movements and shoulder rotation) for the starting and final positions of the throwing motion for each throwing form. Once these positions had been compared to a physical example and established to be with a reasonable range, linear movement was imposed between the two positions for each form. This motion provided basic analysis of both throwing forms as well as inverse dynamic data to attempt forward dynamics.

Using the joint moments from inverse dynamic analysis, forward dynamics was attempted, but the motion was not correct. Due to time constraints on the project, forward dynamics was not a primary concern, so efforts to pursue corrections were minimal.

Results

The results of the project coincide with known real dynamics of a lacrosse throw. A player using the experienced throwing form will have a higher head velocity than a player using an inexperienced form, both of which can be seen in the Appendix – Figure 5. Since no ball was actually used in the simulation, head velocity was used as a measurement of comparison between the two models. Higher head velocity will in turn directly result in higher ball velocity. Using the analysis tools in OpenSim, the forward (x-direction) velocity of the head for each throwing form was found (Appendix – Figure 6). The head velocity of the inexperienced player form was found to have a maximum of 2.62 meters per second (5.86 mph). The head velocity for the experienced player form was 3.46 meters per second (7.74 mph). These values are comparable with experimental estimates of 2.77 meters per second and 3.69 meters per second, respectively, for the inexperienced and experienced throwing forms.

Discussion

This final project report has presented the creation and implementation of an upper body model to demonstrate the differences between inexperienced and experienced lacrosse throwing forms. Through much simplification of the throwing motion, a basic simulation was obtained.

Given the time limitations and scope of the project, there are several limitations to the current model. This model contains no muscles, has no degrees of freedom in the fingers, and has no upper body trunk movement. Actual experimental values were also estimated using a GoPro HD Hero2 camera (Woodman Labs, Inc.) and a background with foot-wide columns of alternating black and white to measure speed in meters per second.

Future work is necessary to provide a definitive comparison of the two throwing forms. This will also require the use of motion capture experimental data, as well as including muscles in the arms and more degrees of freedom in the hand to allow the fingers to close. Adding muscles will allow more advanced use of forward dynamic simulation.

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APPENDIX

Figure 1. Typical lacrosse stick configuration. The shaft is metal, usually a titanium alloy; the head is plastic; the net is usually mesh, with laces across for ball control.

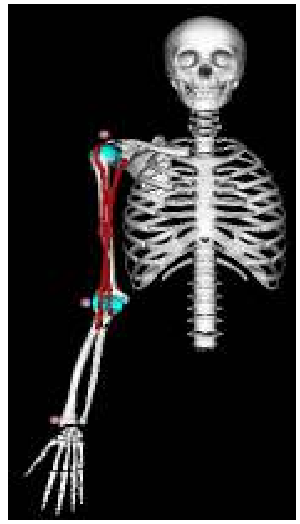

Figure 2. Arm26 example from the Opensim download file.

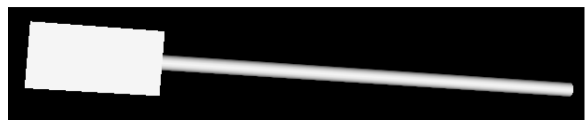

Figure 3. Model substitute of a complete lacrosse stick (shaft and head).

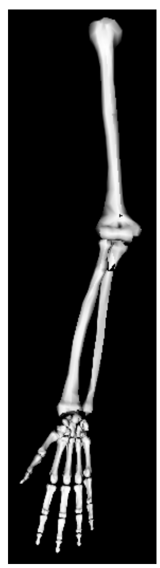

Figure 4. Right arm of the model comprised of three separate bodies: humerus, ulna and radius, and hand.

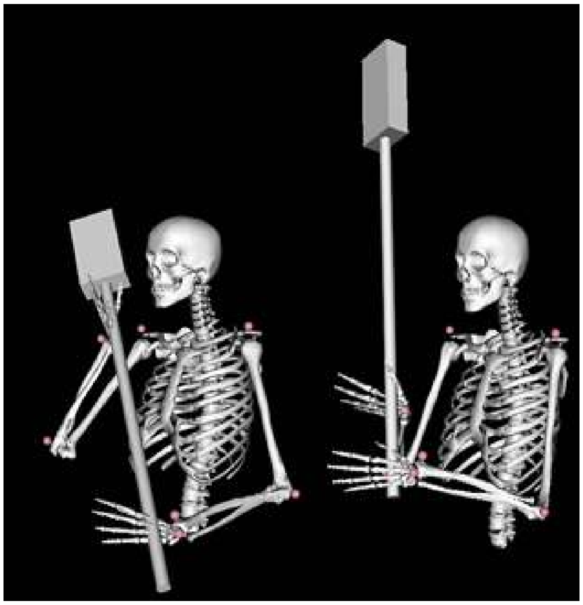

Figure 5. Comparison of the two throw forms from the completed model. Left: inexperienced player; right: experienced player.

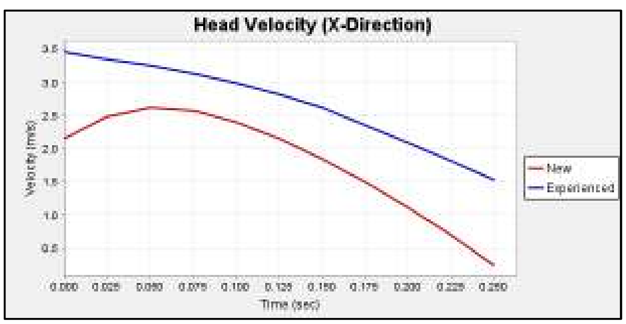

Figure 6. Head velocity comparison for both throwing motions.