Lecture 2

SIMM Overview

EML 5595
Mechanics of the Human Locomotor System

Outline

- Journal Article Review
  Delp and Loan (2000)
- SIMM Overview
- SIMM Tutorial 2

Journal Article Review

1. Why is SIMM a useful tool?

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2. How are SIMM models created?

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4. How are muscle models in SIMM created?

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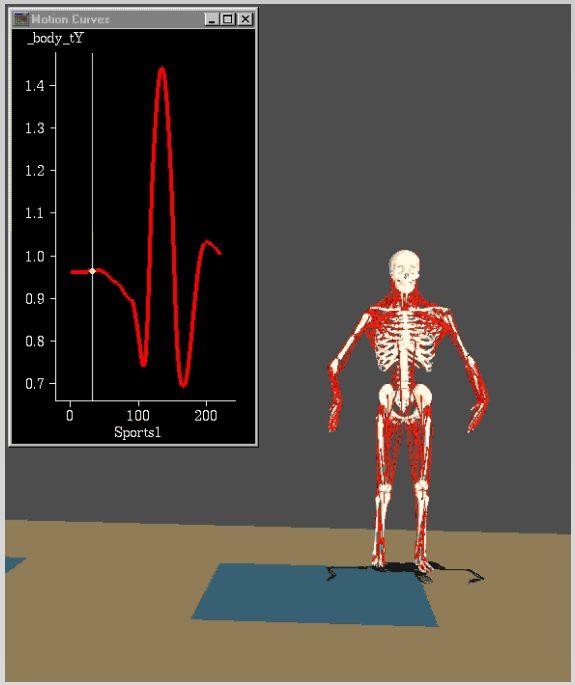
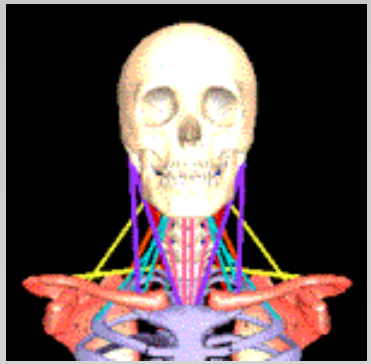
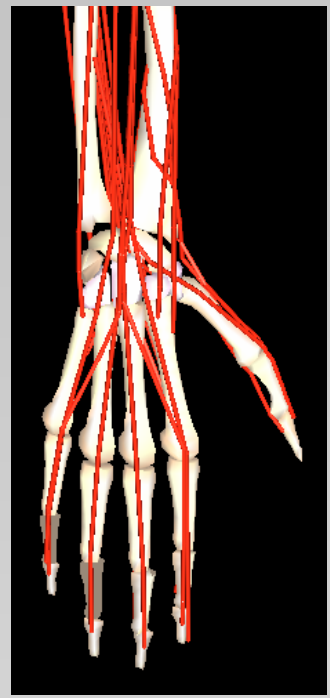
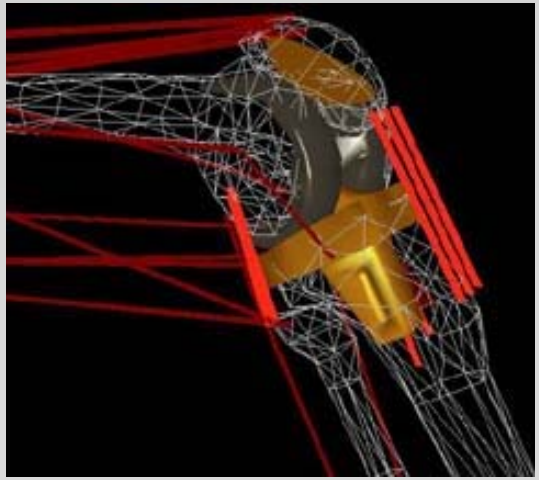
1. Why is SIMM a useful tool?
2. How are SIMM models created?
3. What components comprise a SIMM model?
4. How are muscle models in SIMM created?
5. What are the limitations of SIMM? How can these be overcome?

SIMM Overview

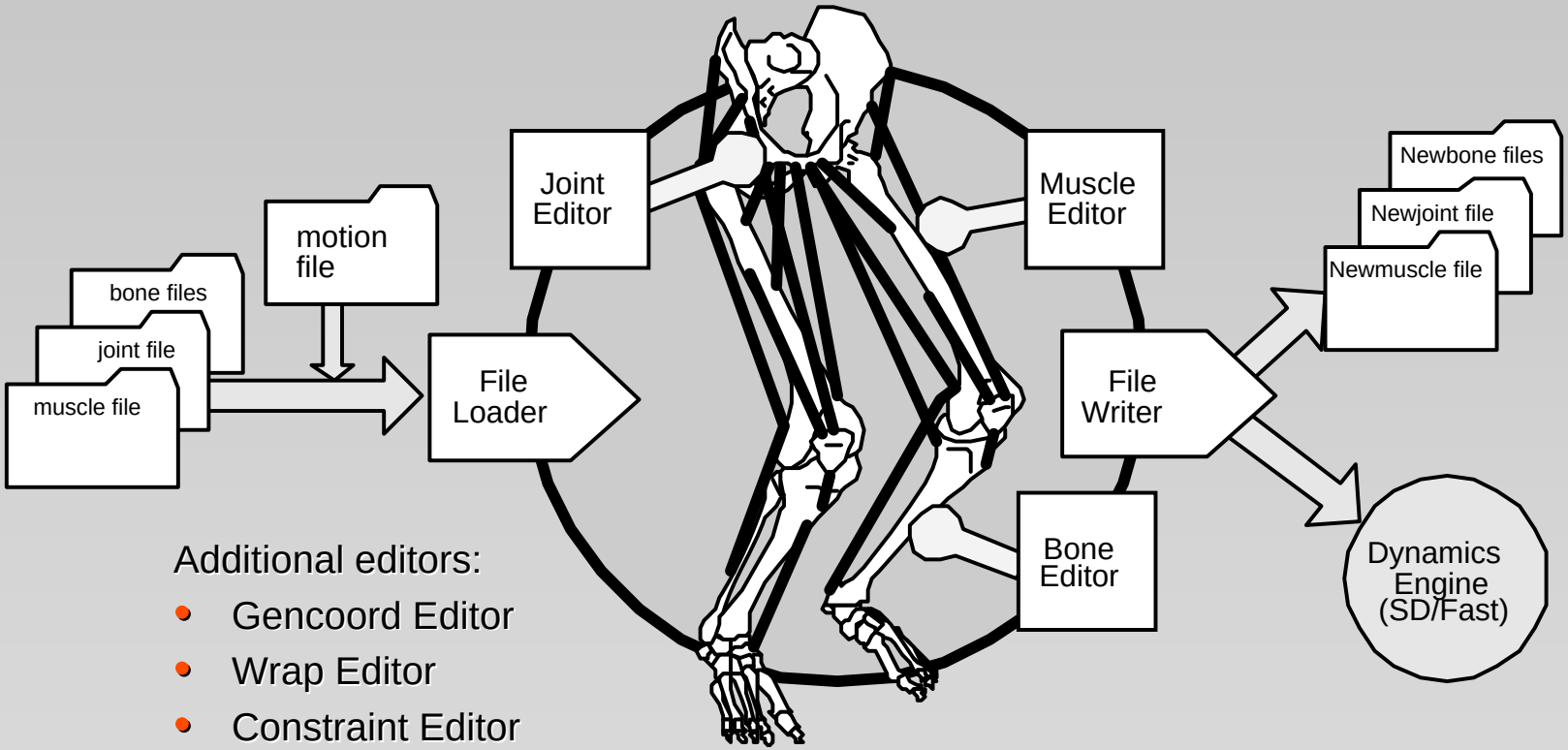








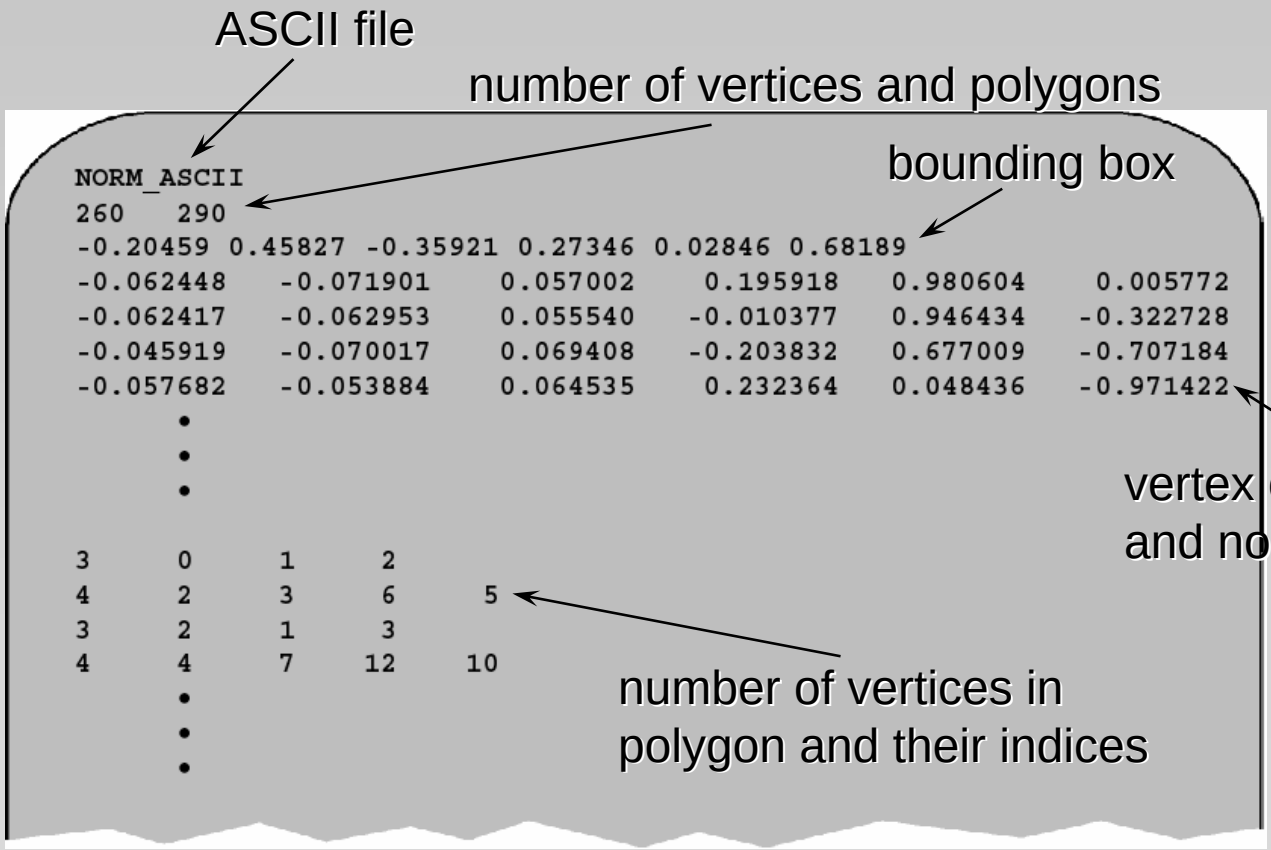
Software Structure



Additional editors:

- Gencoord Editor
- Wrap Editor
- Constraint Editor
- Deform Editor
- Marker Editor

Bone Files



Usually created from existing bone files

Joint Files

- Body segments
- Joints
- Generalized coordinates
- Kinematic functions
- Restraint functions
- Wrap objects
- Constraint objects
- Other stuff

Body Segments

```
/* BODY SEGMENT: right lower leg */
beginsegment right_shank          /* name of this body segment */
bone r_tibia.asc wireframe         /* this bone uses the default material */
bone r_fibula.asc flat_shading my_mat /* this bone overrides the default */
                                      /* material and drawmode */
begingroups
right_leg lower_body               /* this segment belongs to two groups */
endgroups
drawmode flat_shading             /* override default and use flat shading */
material my_bone_mat               /* override default, which is def_bone */
shadow Y -0.9                     /* draw the shadow directly below */
shadowcolor 40 40 40              /* use a dark gray for the shadows */
axes 0.2                          /* show reference frame, w/axes 0.2 long */
endsegment
```

Easy to create with an input file

Joints

```
/* FEMORAL-TIBIAL JOINT */
beginjoint femoral-tibial      /* name of this joint  */
segments femur tibia           /* joint from FEMUR frame to TIBIA frame */
order t r1 r2 r3               /* translate, then rotate about axis1, axis2,
                                  and axis3 */

axis1 0.0 0.0 1.0
axis2 1.0 0.0 0.0              /* rotation axis definitions */
axis3 0.0 1.0 0.0
loopjoint                      /*
show axis1 0.2                 /* display rotation axis1, length = 0.2 */
tx function f1 (knee_angle)    /* The kinematic functions f1 and f2 */
ty function f2 (knee_angle)    /* specify the relations between the */
tz constant 0.0                /* generalized coordinate (knee_angle) */
r1 function f3 (knee_angle)    /* and tx and ty, the translations in  */
r2 constant 0.0                /* the x and y directions, respectively. */
r3 constant 0.0                /* f3 specifies the relation between */
endjoint                       /* knee_angle and the rotation around axis1. */
```

Easy to create with an input file

Generalized Coordinates

```
/* Generalized Coordinate: knee angle */
begingencoord knee_angle          /* name of gencoord */
begingroups
right_leg lower_body
endgroups
range    0.0 -120.0               /* range of motion for this gencoord */
keys  k_key                       /* press this key to flex the knee */
default_value  -30.0              /* starting, and default value of gencoord */
wrap                              /* lets you loop through range of motion */
endgencoord
```

Easy to create with an input file

Kinematic Functions

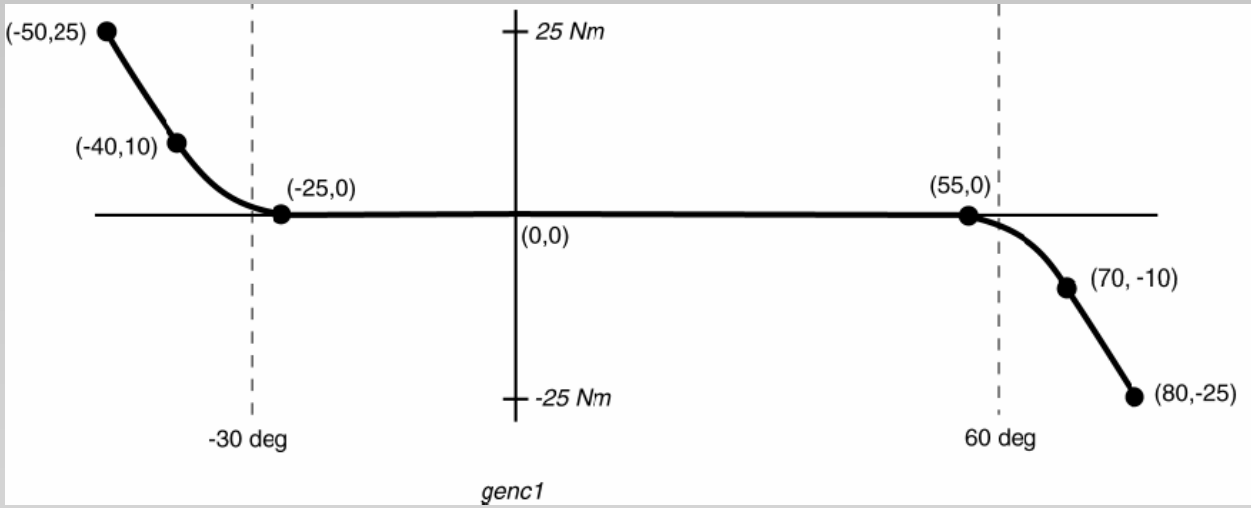
```
/* KINEMATIC FUNCTION: Tx of the femoral-tibial joint */
beginfunction f1 /* defines x translation from femur to tibia */
/* knee_angle (degrees), tx (meters) */
(-120.0,-0.003)
(-100.0, 0.001)
( -80.0, 0.004)
( -60.0, 0.004)
( -40.0, 0.002)
( -20.0,-0.001)
( -10.0,-0.003)
(   0.0,-0.005)
endfunction
```

Easy to create with an input file
or modify with the Joint Editor

Restraint Functions

```
begingencoord genc1
range -30 60
restraint f31
endgencoord

beginfunction f31
(-50.0, 25.0)
(-40.0, 10.0)
(-25.0, 0.0)
(-25.0, 0.0)
(55.0, 0.0)
(55.0, 0.0)
(70.0, -10.0)
(80.0, -25.0)
endfuntion
```



Easy to create with an input file
or modify with the Gencoord Editor

Wrap Objects

```
/* Example Wrap Object */
beginwrapobject hip_wrapper
wraptype ellipsoid
segment pelvis
xyz_body_rotation 20.0 0.0 0.0
translation -0.0826 -0.0286 0.0808
radius 0.05 0.02 0.05
active yes
visible no
quadrant -y
endwrapobject
```

Easiest to create with the Wrap Editor

Constraint Objects

```
/* Example constraint object */
beginconstraintobject r_scapula_con
constrainttype ellipsoid
segment ribcage
xyz_body_rotation -9.12 16.21 10.42
translation -0.0399 0.1799 0.0743
radius 0.0800 0.1800 0.0800
active yes
visible no
quadrant -x
beginpoints
/* name     X         Y         Z      weight   segment   tolerance */
    c1   -0.0900   -0.1800   -0.0520   1.0000   r_scapula   0.001
    c2   -0.0950   -0.1400   -0.0700   2.0000   r_scapula   0.001
    c3   -0.0550   -0.0900   -0.0550   1.0000   r_scapula   0.002
endpoints
endconstraintobject
```

Easiest to create with the Constraint Editor

Other Stuff

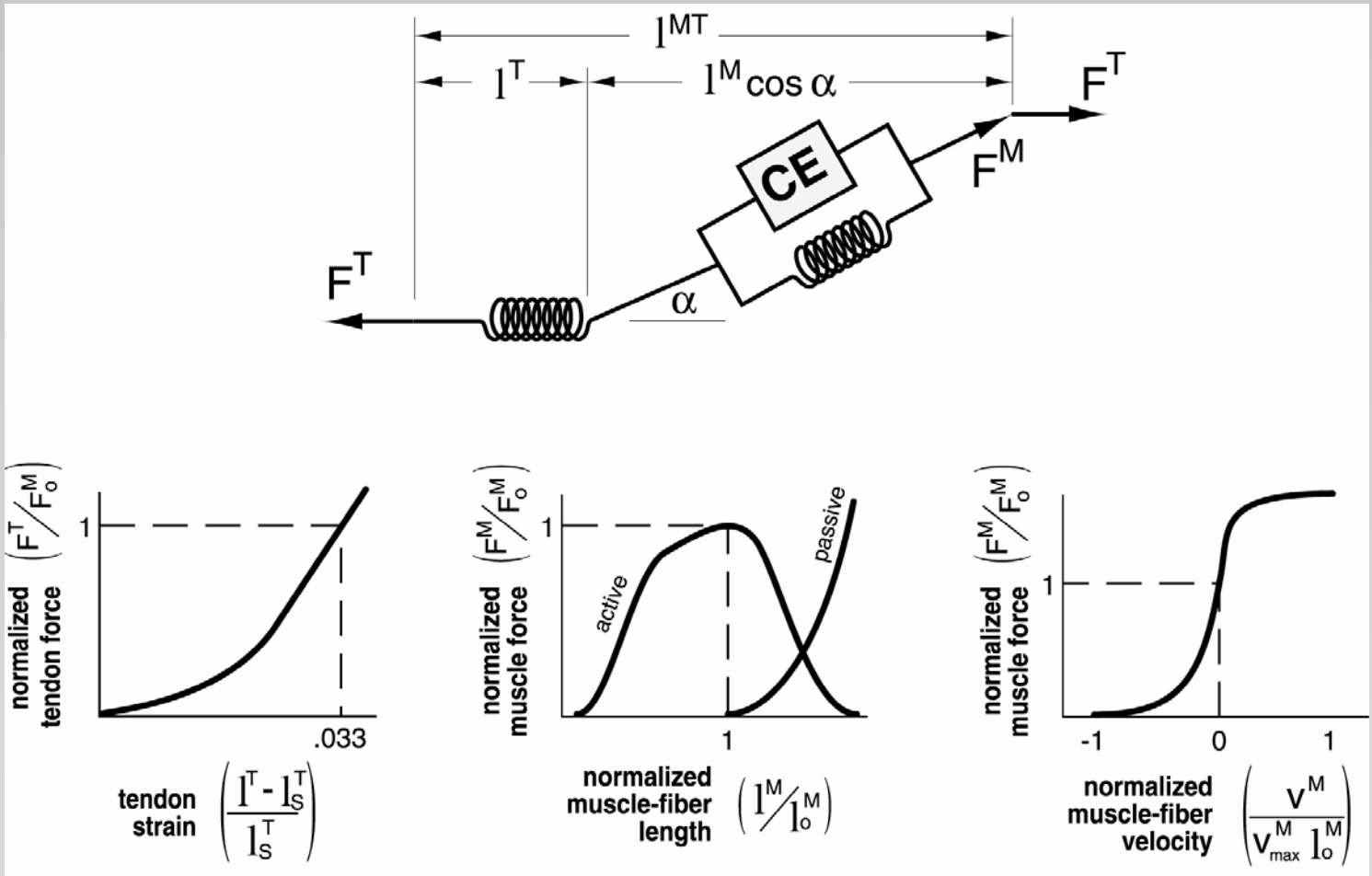
- Fixed segment
- Materials
- Cameras
- Deform objects
- Deformities
- Motion objects

Muscle Files

```
/* Rectus Femoris muscle */
beginmuscle RectusFemoris
beginpoints
-0.029 -0.031  0.096 segment pelvis
 0.033 -0.403  0.001 segment femur ranges 1 knee_angle (-120, -80)
 0.012  0.043 -0.001 segment patella
endpoints
begingroups
hip_flexion
knee_extension
endgroups
wrapobject distal_femur_ell midpoint range 1 -1
max_force               780.0     /* Newtons */
optimal_fiber_length    0.0840    /* meters  */
tendon_slack_length     0.3460    /* meters  */
pennation_angle         5.0       /* degrees */
min_thickness 0.004
max_thickness 0.008
min_material muscle_min
max_material muscle_max
endmuscle
```

Easy to create with an input file
or modify with the Muscle Editor

Default Muscle



Motion Files

```
/* One-legged walking motion */

name gait_cycle          /* name of this motion */
datacolumns 6            /* 6 columns of data */
datarows 100             /* 100 rows of data, 1 for each motion time step */
range 0.0 100.0          /* 0 to 100% of gait cycle */
keys g_key               /* press this key to make the model walk */
wrap                     /* so you can "walk" the model continuously */
cursor 1.0 1.0 0.0       /* cursor in plot windows will be yellow */
event 40.0 heelstrike    /* heelstrike will be displayed in plot windows */
event_color 1.0 0.0 1.0 /*    as a magenta vertical bar */
enforce_loops no         /* enforce loops when animating motion? */
enforce_constraints no   /* enforce constraint objs when animating motion? */
calc_derivatives 0.01    /* seconds between each frame of data, so SIMM
endheader                /*    can calculate derivatives of motion curves */

hip_flexion    knee_angle    rf    semimem     knee_mom  hip_flexion_vel
  17.3492       -21.7508    0.22     0.10      33.4217       0.0000
  13.8255       -21.2797    0.25     0.10      35.8324      -1.8606
  12.3931       -20.5520    0.25     0.00      38.0823      -3.6857
   9.8606       -19.2399    0.35     0.00      40.0734     -12.2093
   7.3476       -19.0344    0.35     0.00      42.9230     -11.5651
   6.0183       -19.0093    0.37     0.00      43.1642     -10.8911
   5.6743       -18.2846    0.37     0.00      45.3475      -9.7498
        .
        .
        .
```

Easy to create with an input file using experimental data

Plot Files

```
# Ankle plantarflexion moment
# Sale, D.J., et al., Influence of joint position on
# ankle plantarflexion in humans, J. Appl. Physiol.:
# Resp. Environ, Exercise Physiol. 52(6): 1636-1642, 1982
# pos angles = dorsiflexion
# neg angles = plantarflexion

title   ankle_angle moment vs. ankle_angle

ankle_angle     Sale (ave 90) | ankle_angle moment
                Sale (knee 90) | ankle_angle moment

-30.0   -35.0   -38.0
-25.0   -50.0   -40.0
-15.0   -79.0   -63.0
 -5.0  -114.0   -87.0
  5.0  -144.0  -125.0
 15.0  -170.0  -150.0
 20.0  -168.0  -151.0

ankle_angle     Sale (knee ext) | ankle_angle moment
-30.0   -52.0
-25.0   -75.0
-20.0   -87.0
-15.0  -105.0
-10.0  -125.0
 -5.0  -140.0
  0.0  -155.0
  5.0  -165.0
 10.0  -170.0
```

Easy to create with an input file using other data sources

SIMM Tutorial 2

Introduction to Musculoskeletal Modeling

- Become familiar with SIMM's viewing, plotting, and animation features
- Discover some of the limitations of musculoskeletal models
- Explore differences between 1- and 2-joint muscles
- Use SIMM to assess hamstrings length during crouch gait

For Next Time

- Download and work through SIMM Tutorial 2
- Download and read Zajac (1993)