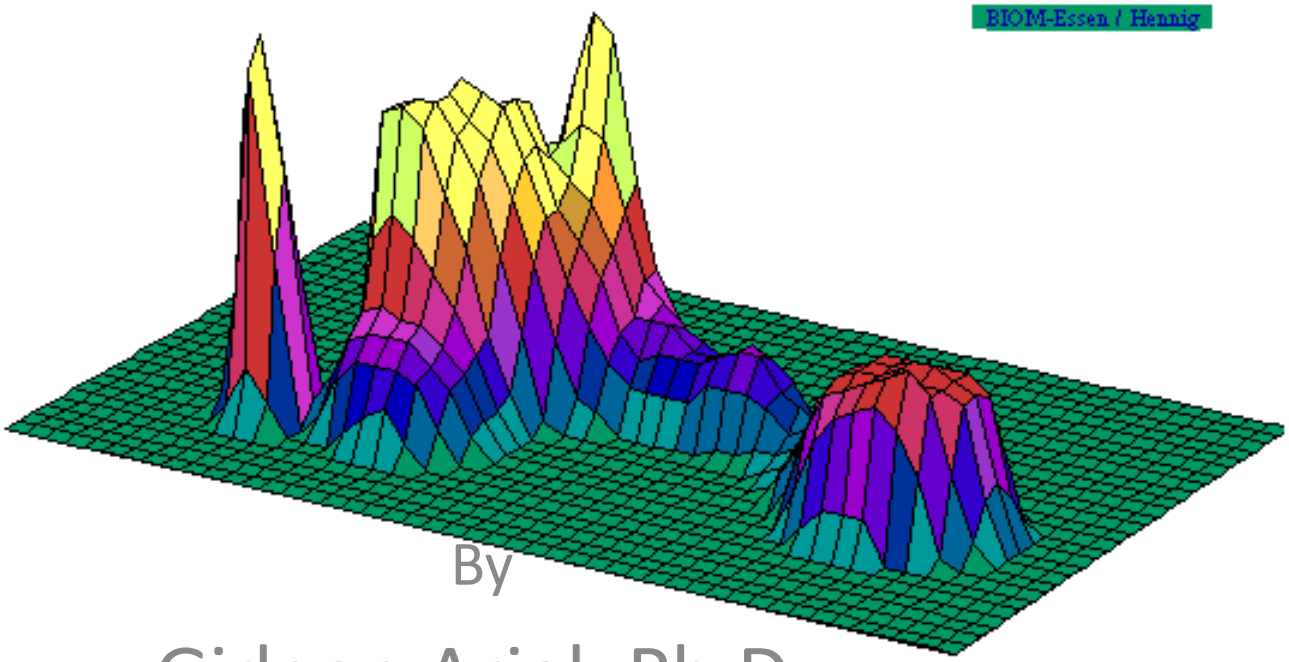
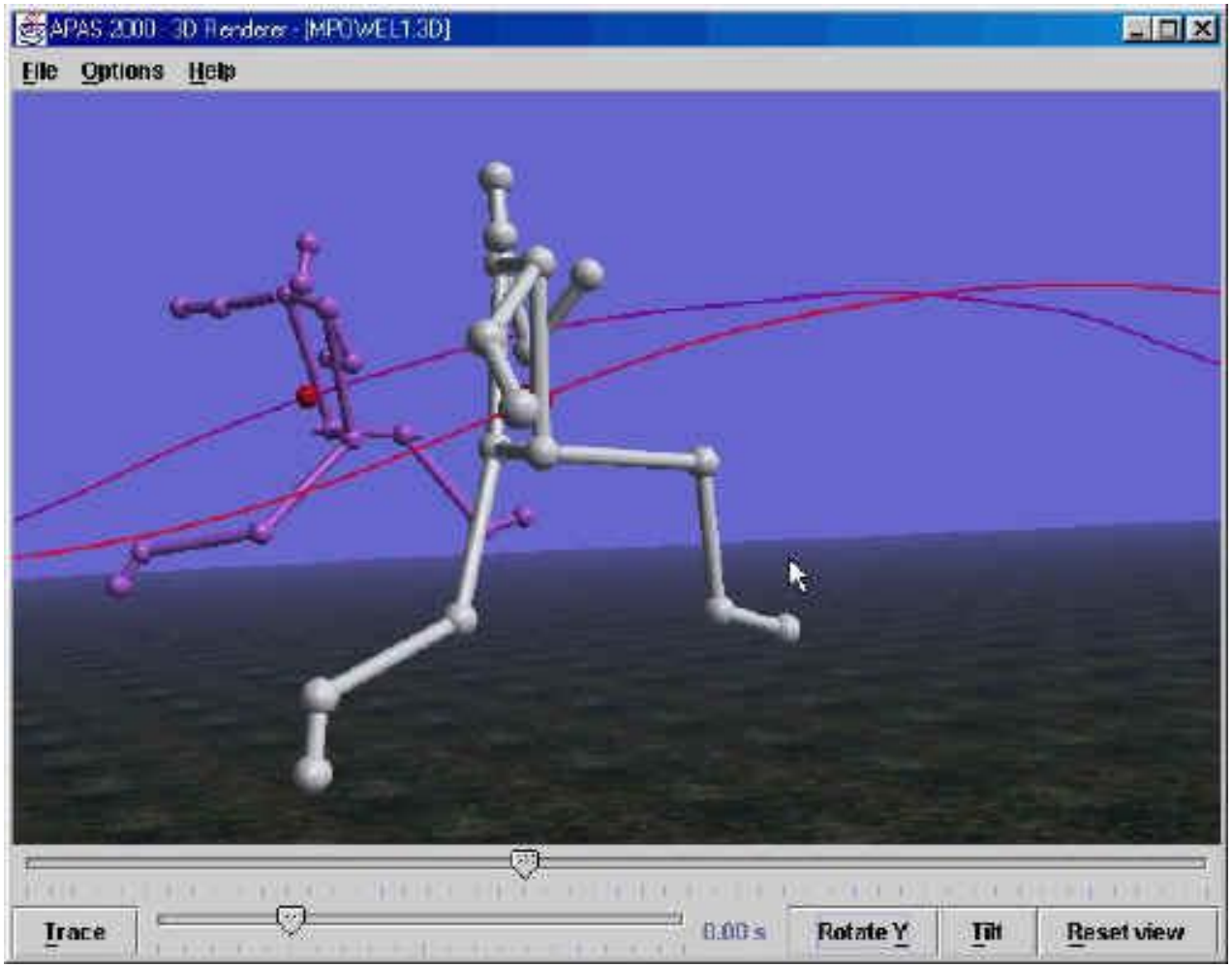
BIOMECHANICAL Integration Of Essential Human Movement Parameters and Technology for 3D Gait Analysis



By

Gideon Ariel, Ph.D.

MOVEMENT ANALYSIS CAN BE APPLIED TO:



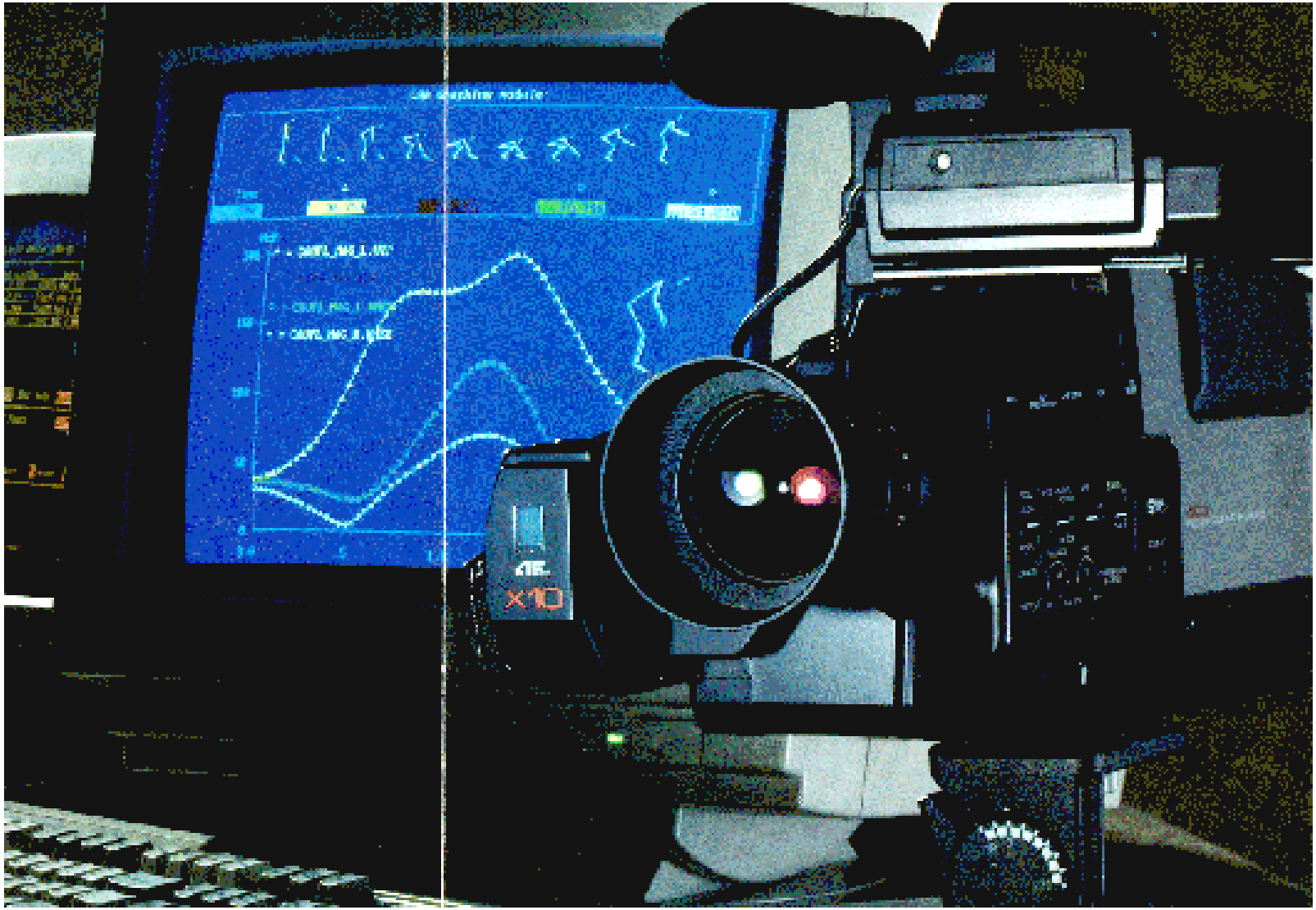
Athletics

Industry

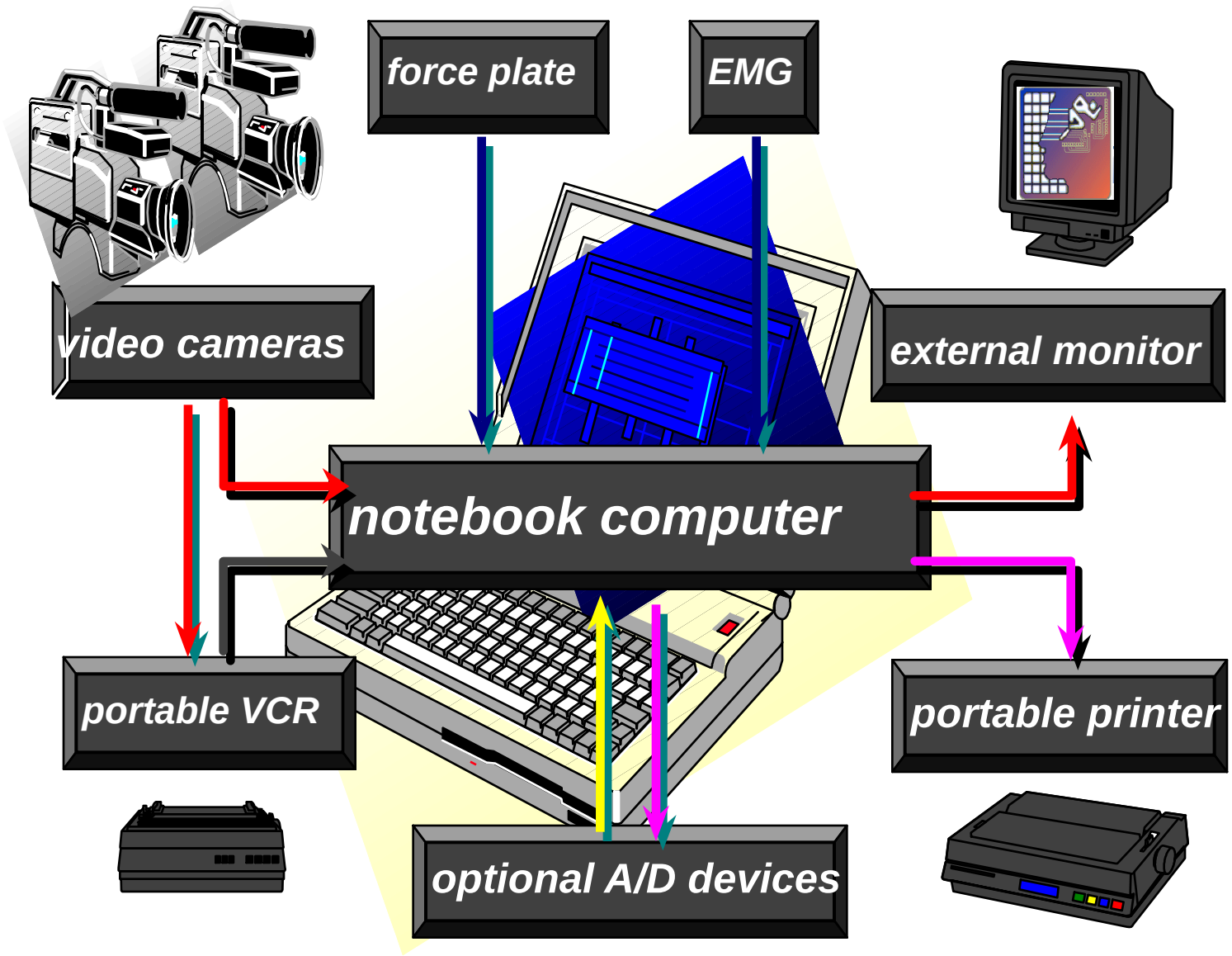
Medicine

Space

ALL APPLICATIONS UTILIZED SIMILAR QUANTIFICATION TECHNIQUES



Basic Components of Motion Analysis System



Analysis of Performance Requires:

Video Recording

Digitizing the Data

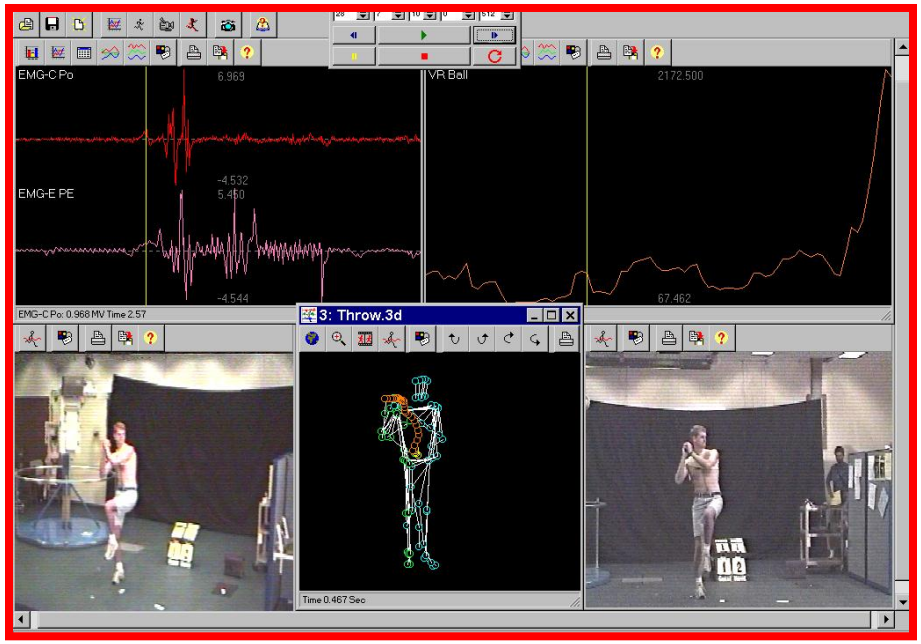
- **Manual**
- **Automatic**

Transformation of the Data

- **2D - Two Dimensional**
- **3D - Three Dimensional**

Hardware

- Main Computer System
- Workstations
- Capture Card
- Network
  - Intranet
  - Internet
    - Renderer
    - Presentations



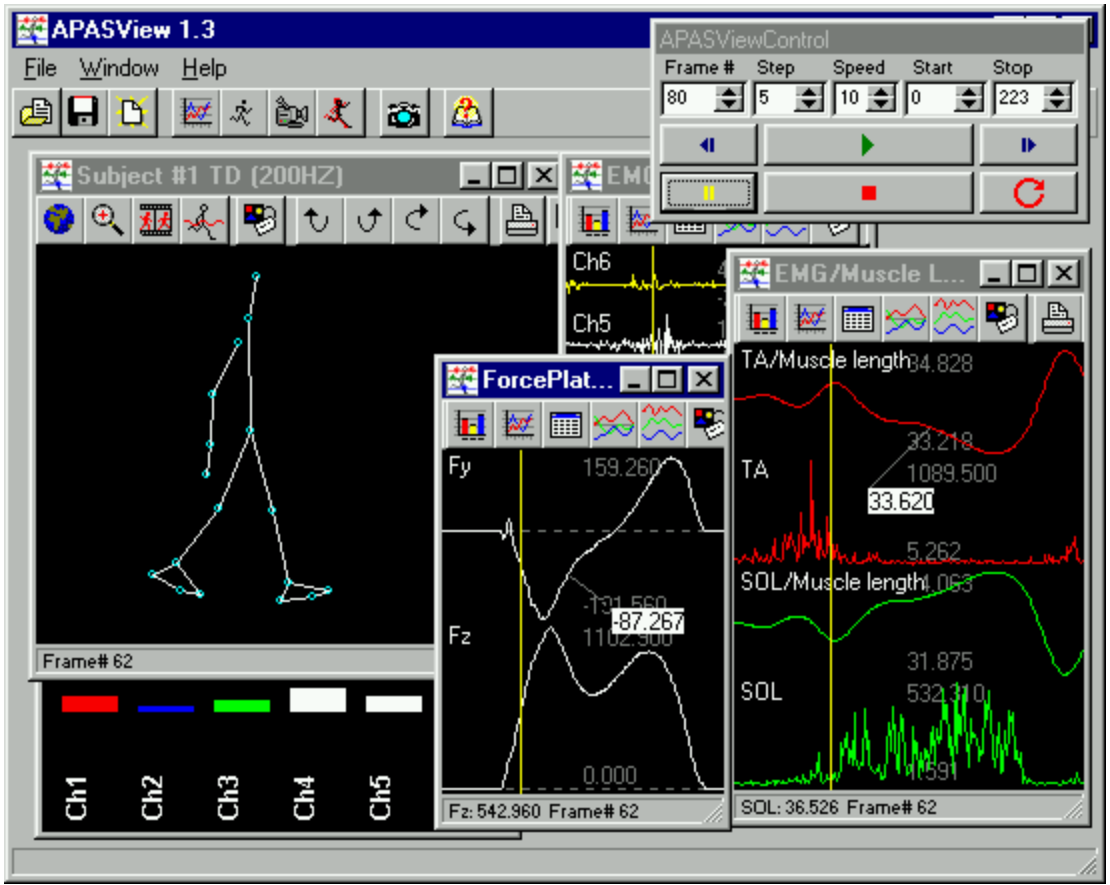
High Speed Camera at 240 Hz

Video Capturing System

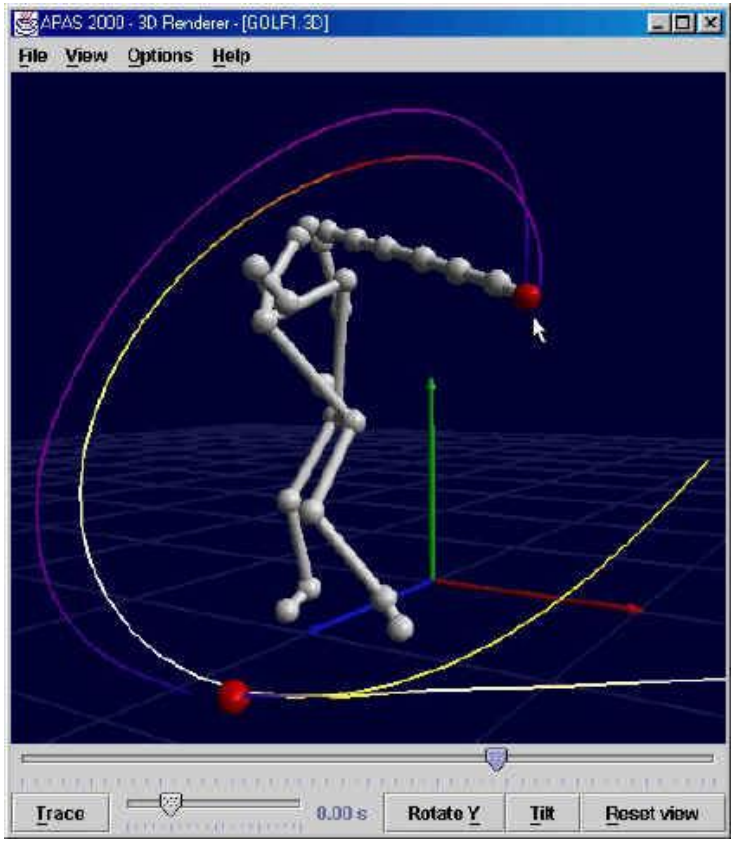
Video Capturing Software Packages

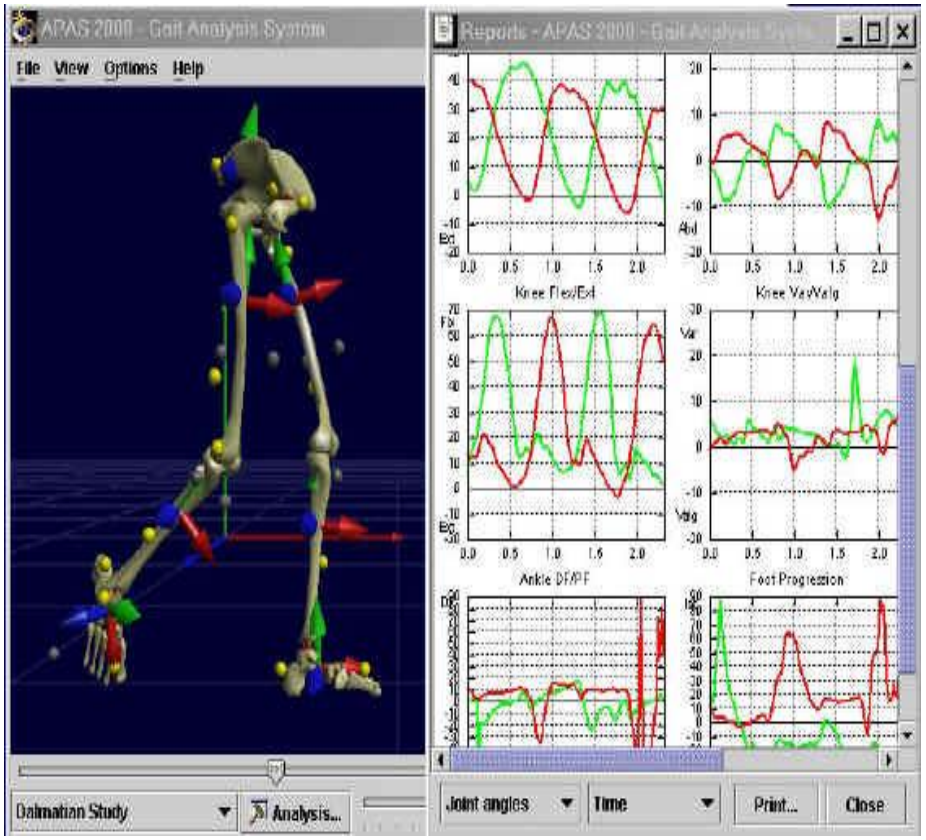
Microsoft HTML Document 5.0

Display and Analysis



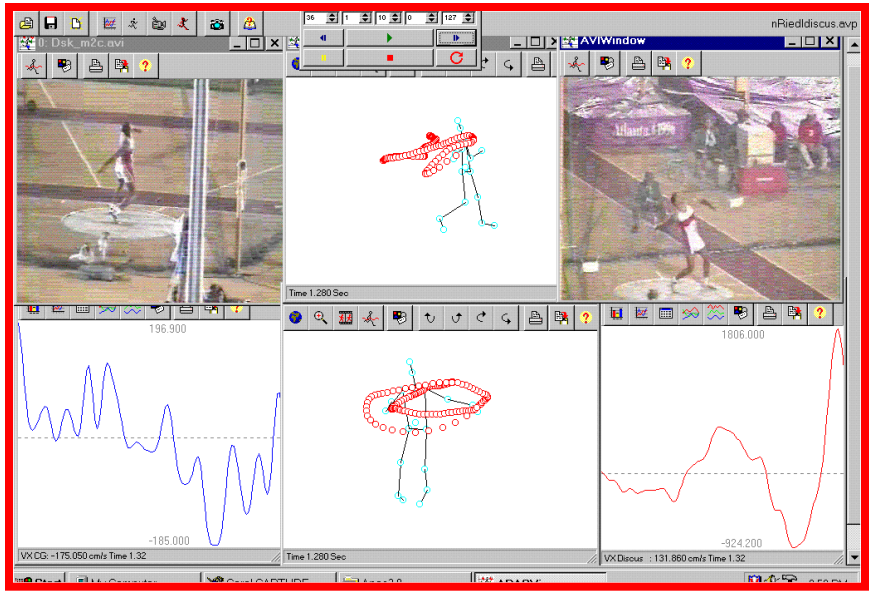
Software Integration

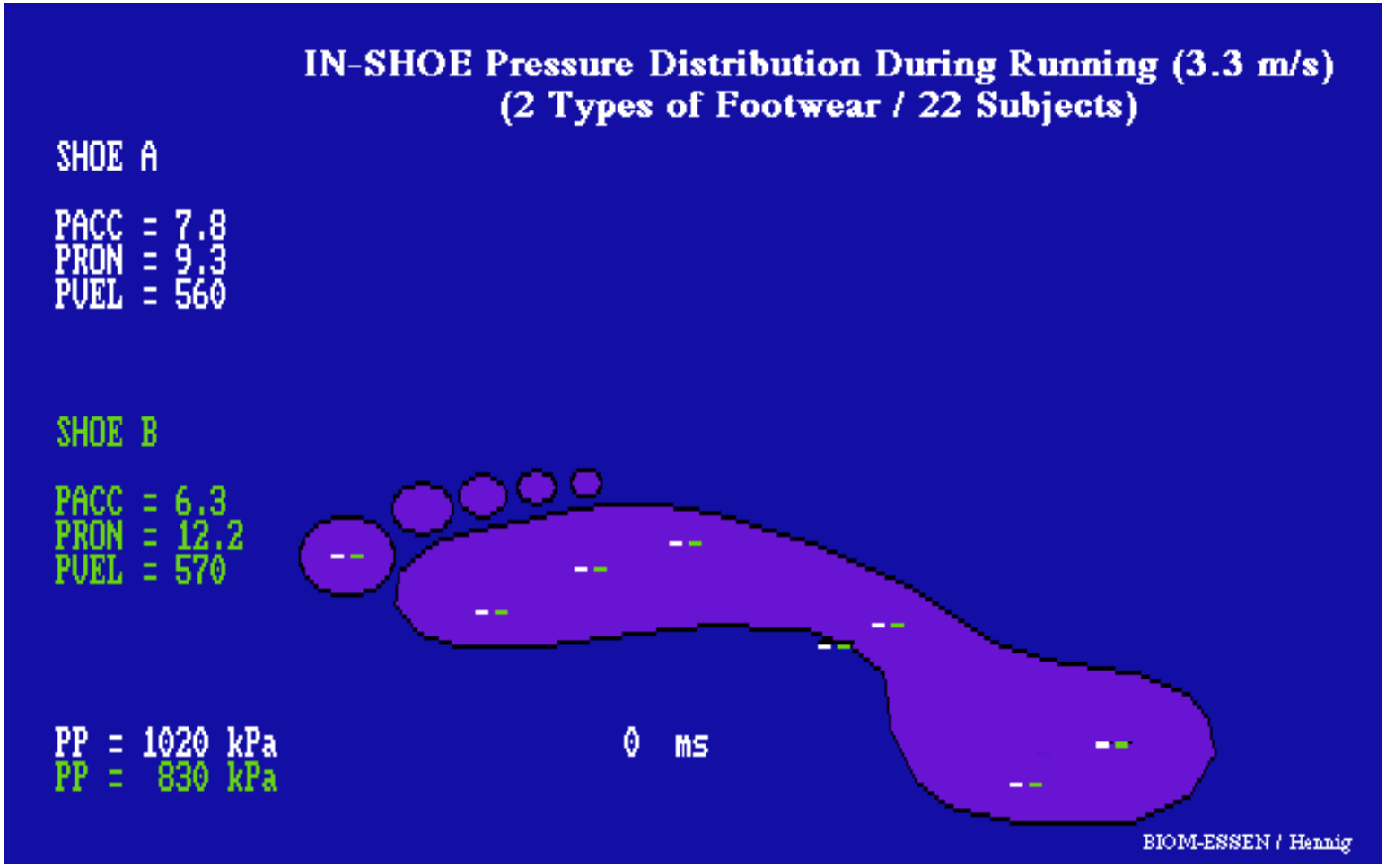


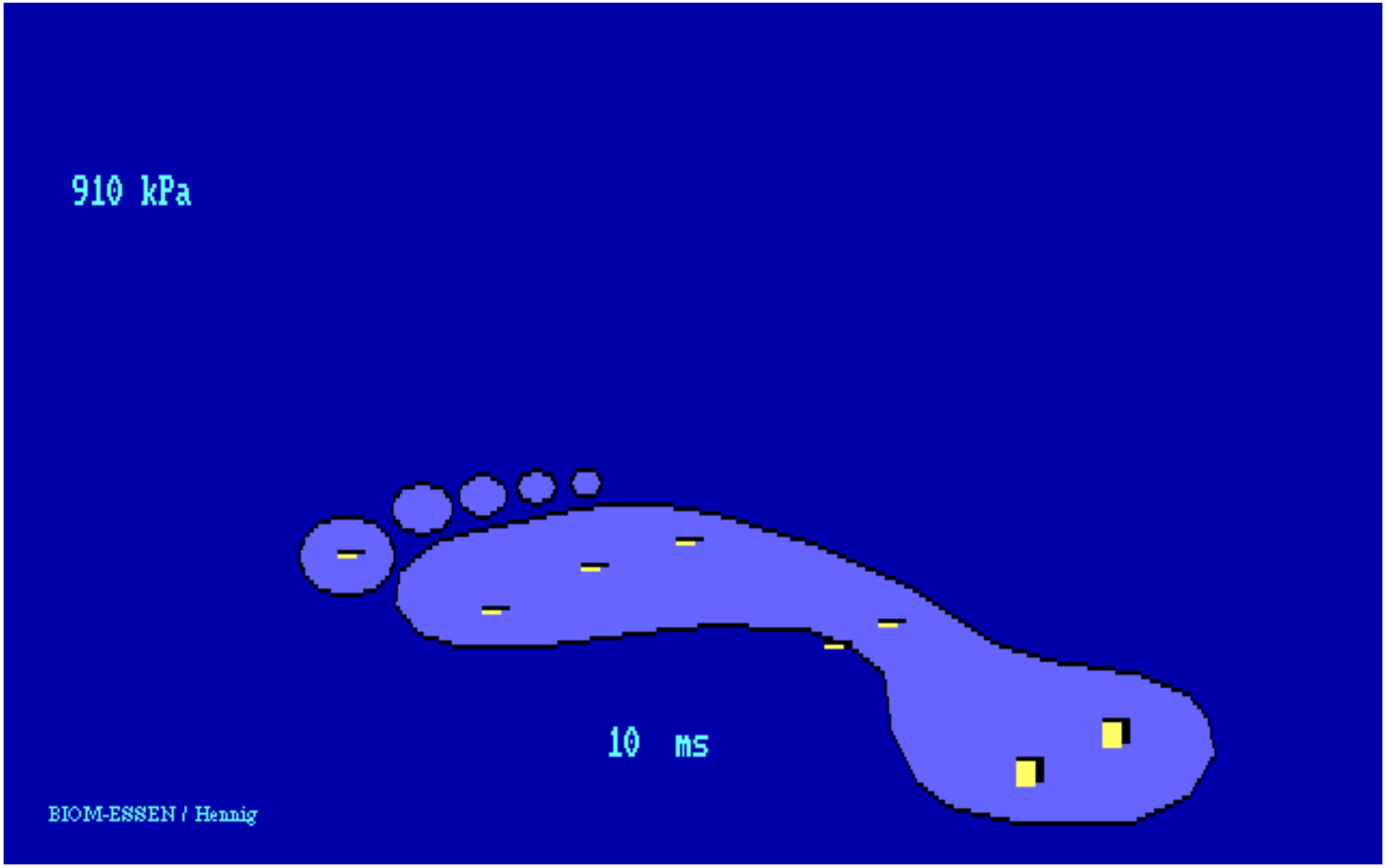


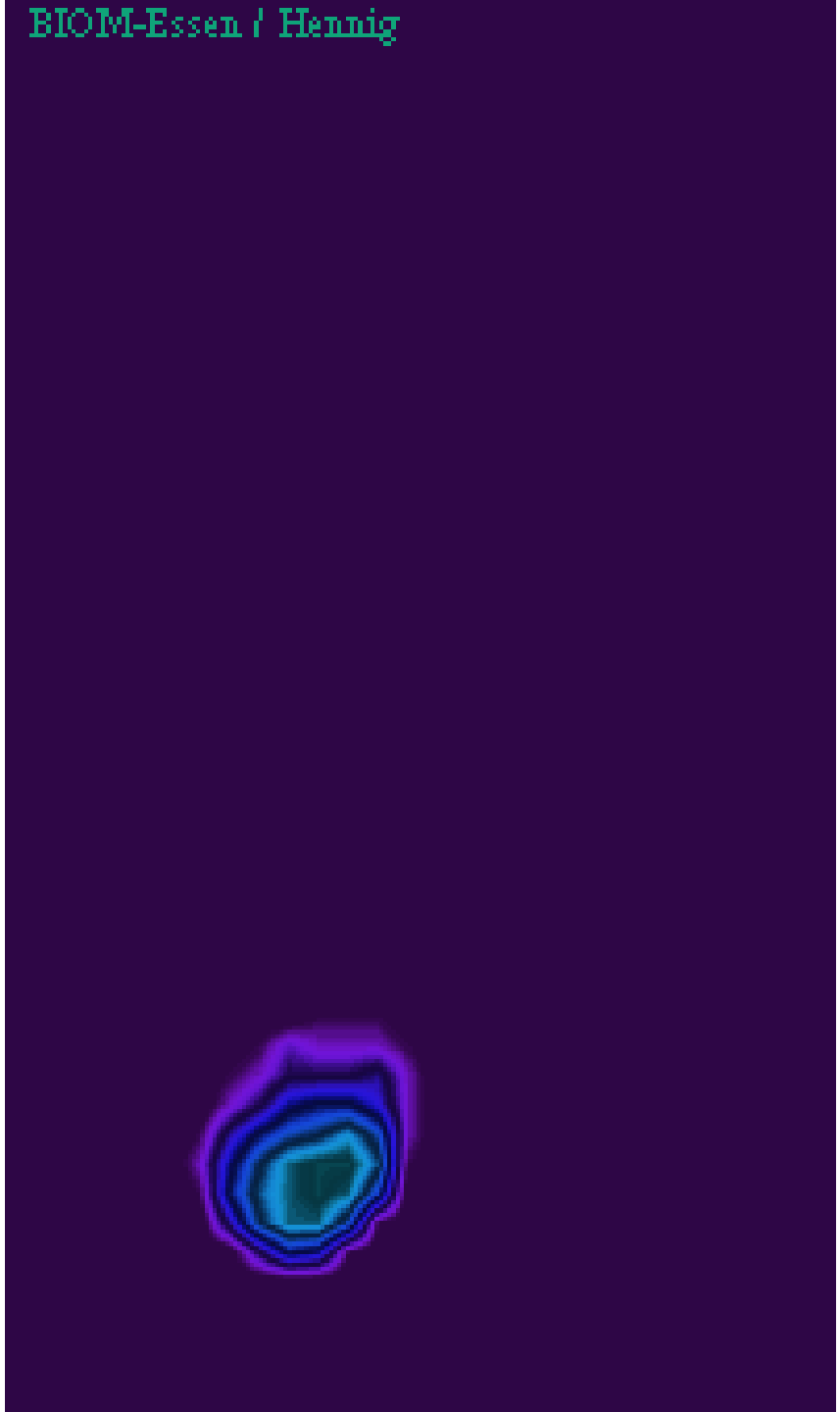
Software Integration

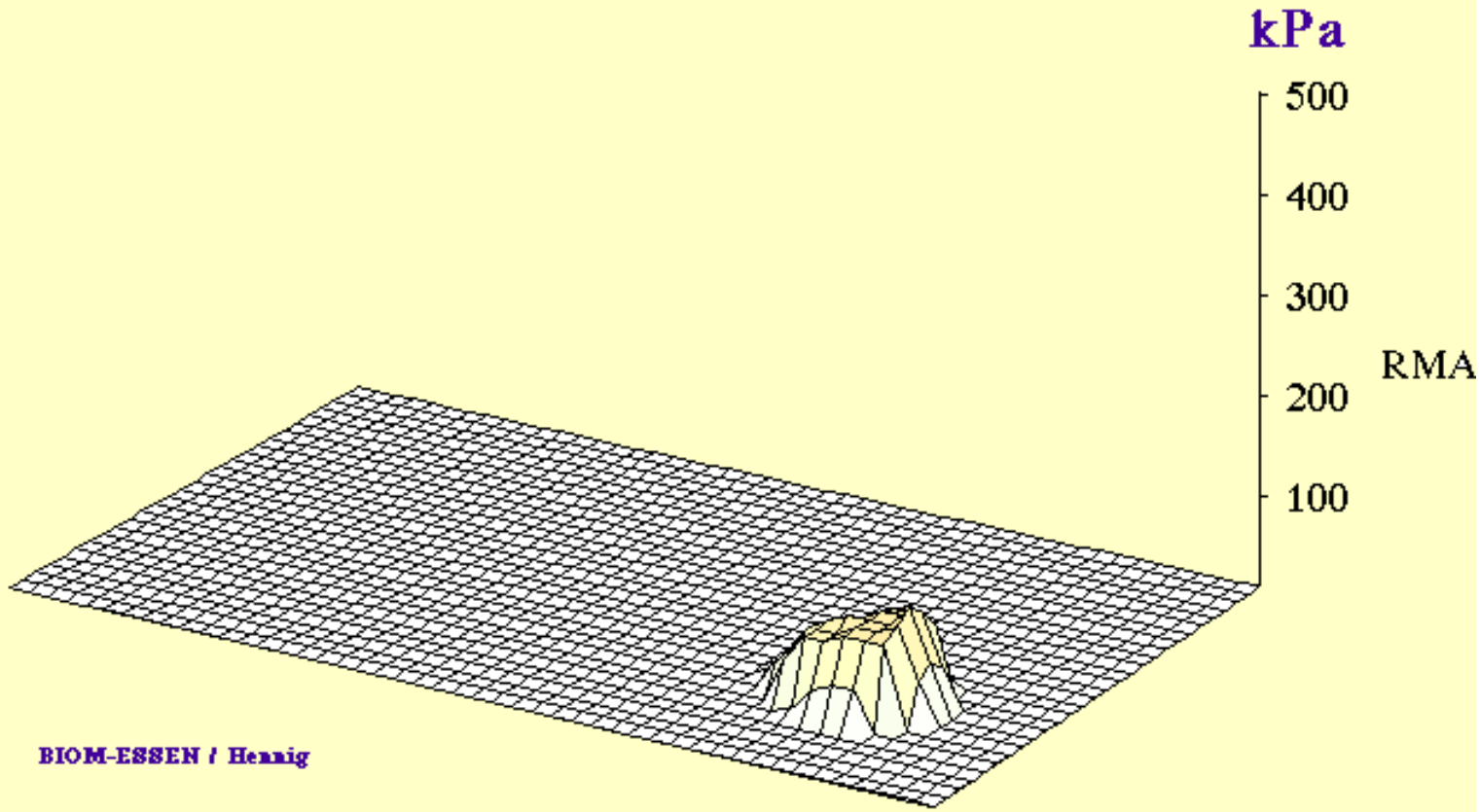
- Capturing
- Digitizing
  - Locally
  - Net Digitizing
- Transformation
- Filtering
- Kinematic Results Display
- Kinetic Results Display




IN-SHOE Pressure Distribution During Running (3.3 m/s)
(2 Types of Footwear / 22 Subjects)
SHOE A
PACC = 7.8
PRON = 9.3
PVEL = 560
SHOE B
PACC = 6.3
PRON = 12.2
PVEL = 570
PP = 1020 kPa
PP = 830 kPa
0 ms
BIOM-ESSEN / Hennig

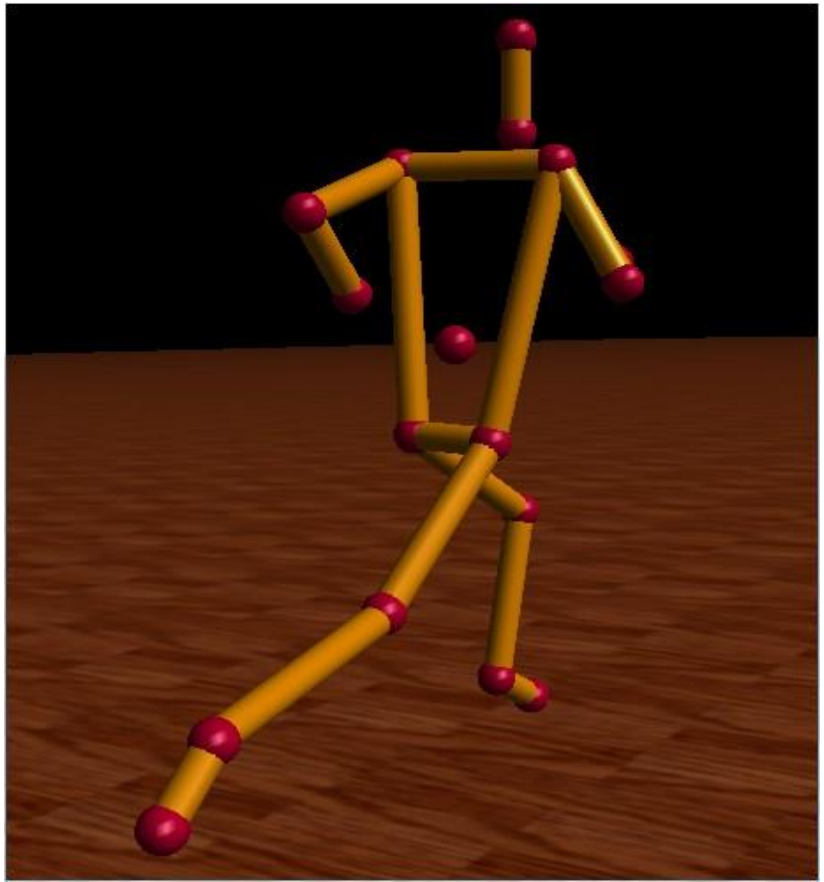

910 kPa
10 ms
BIOM-ESSEN / Hennig

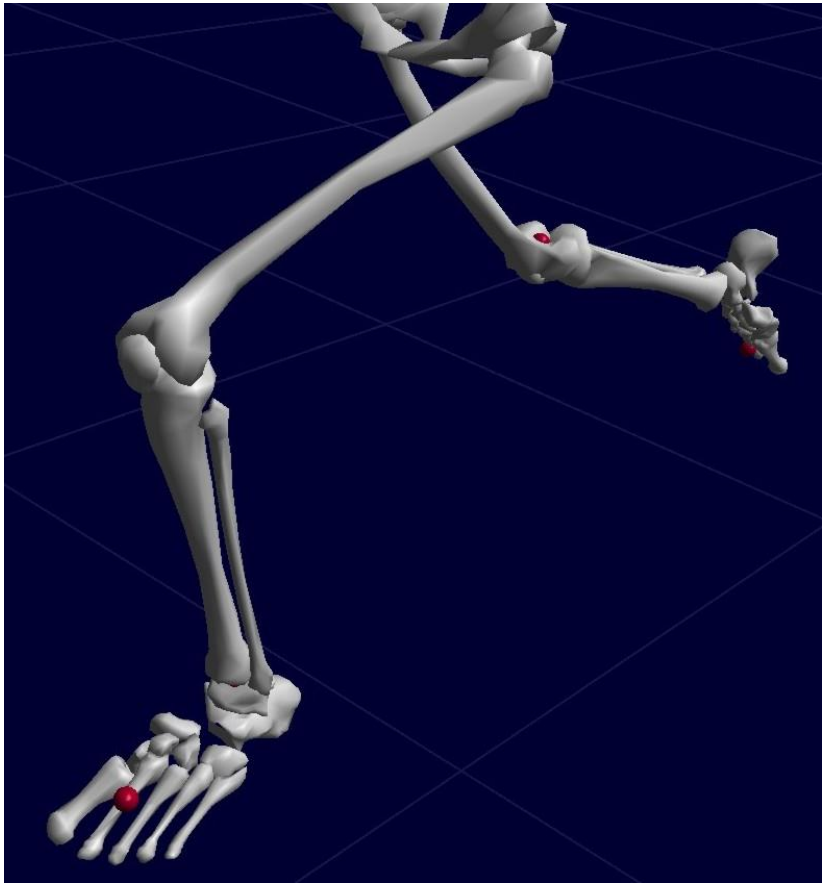

BIOM-Essen / Hennig

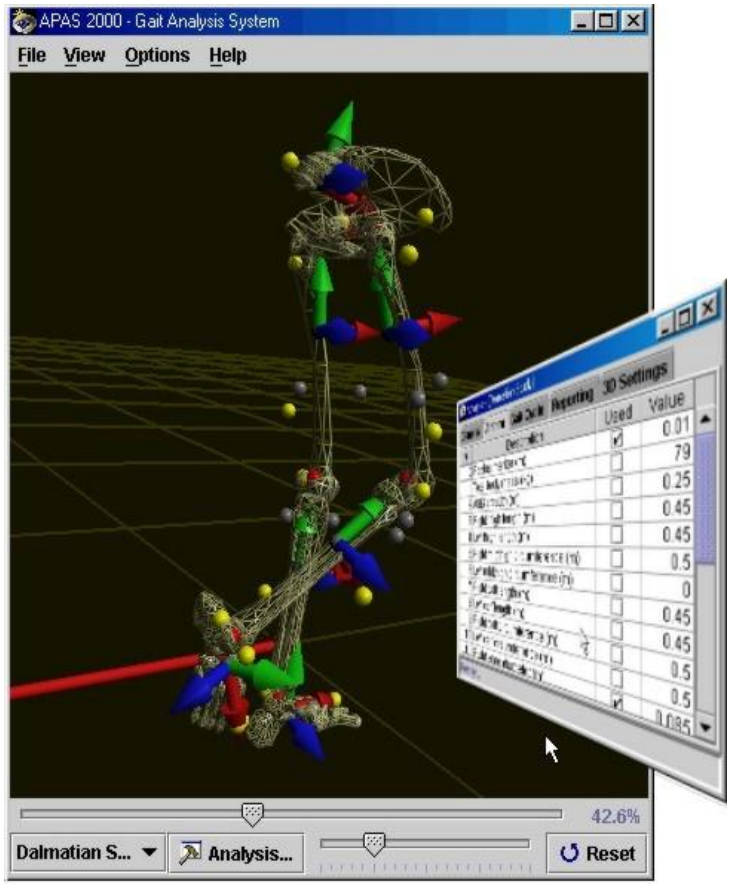

kPa
500
400
300
200
100
RMA
BIOM-ESSEN / Hennig

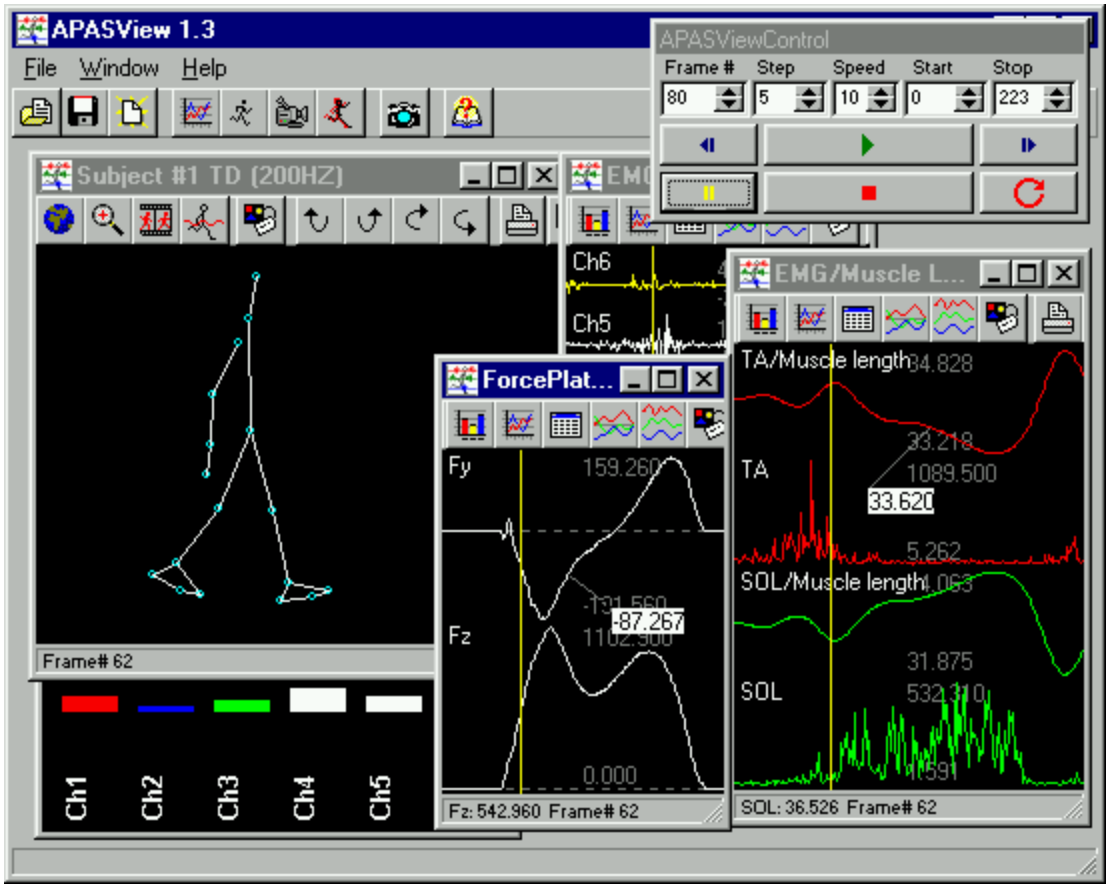
PROVIDE SIMULTANEOUS INTEGRATION OF:

- **Video Images**,
- **3-D Stick Figures**,
- **Kinematic & Kinetic Data in graphic/tabular format**,
- **Analog information from force plate & EMG data**

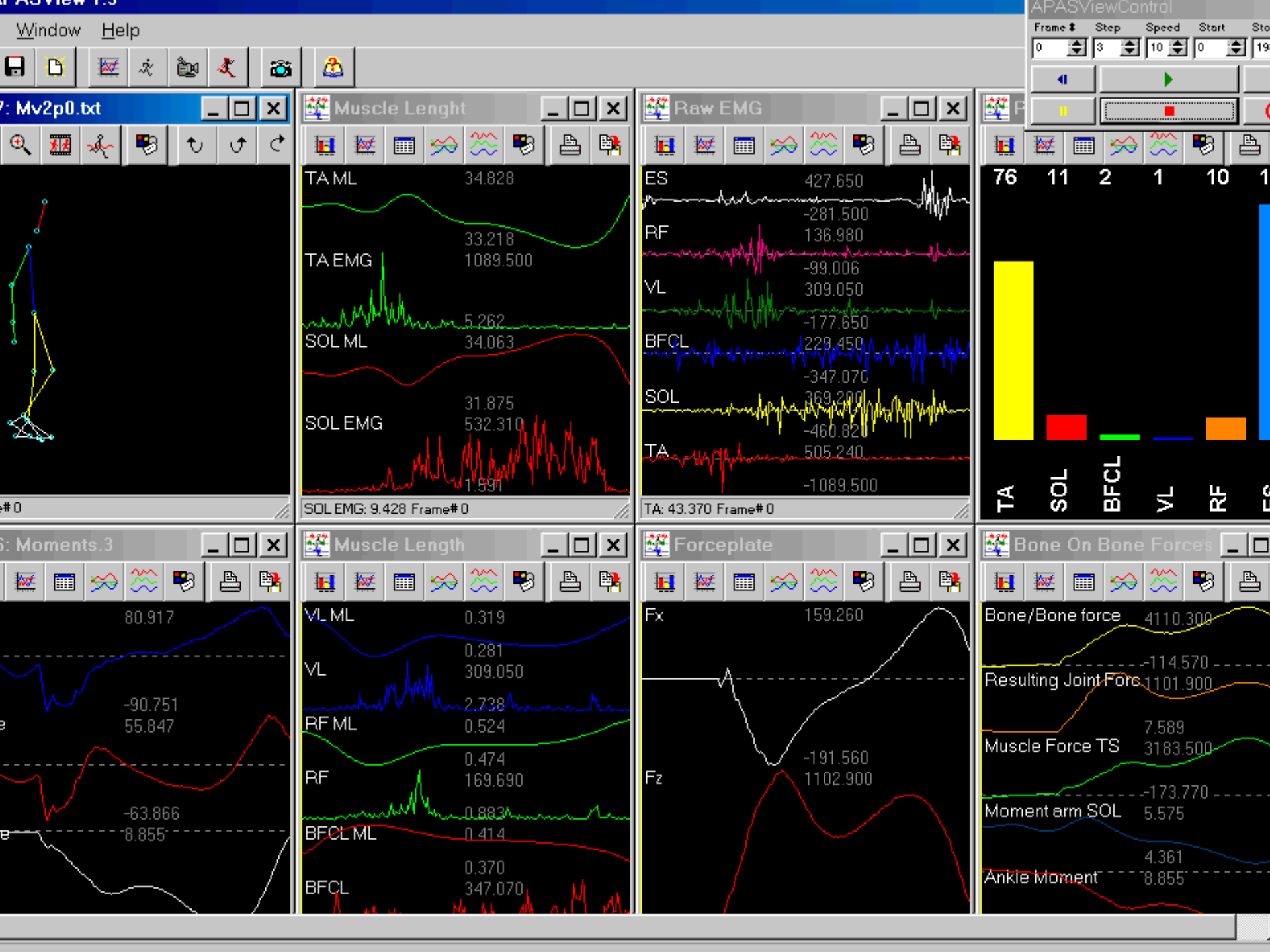


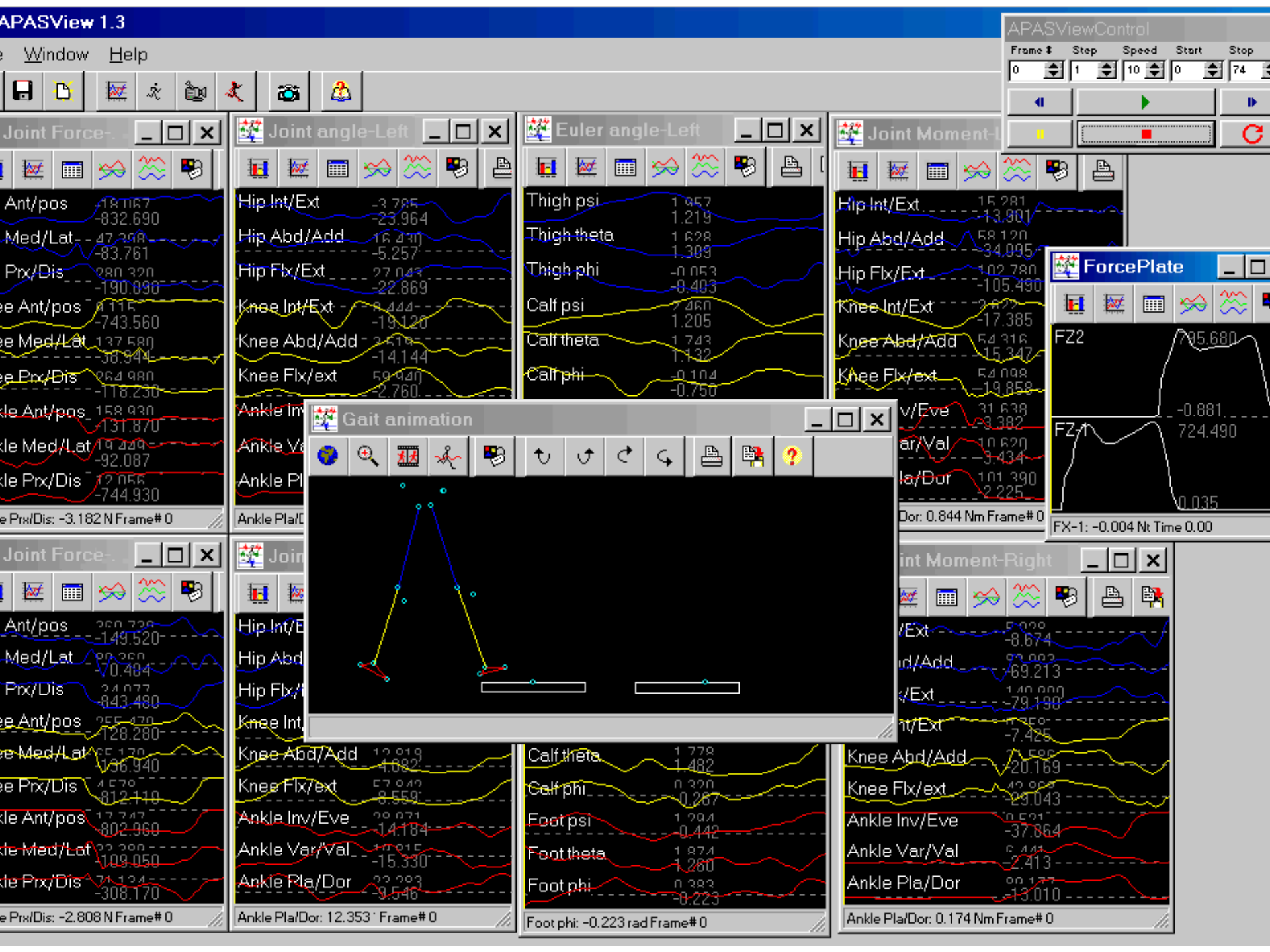



APAS 2000 - Gait Analysis System
File View Options Help
42.6%
Dalmatian S...
Analysis...
Reset

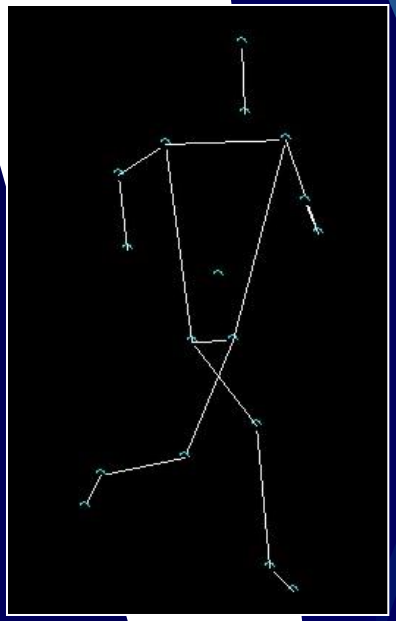

APASView 1.3
File Window Help
APASViewControl
Frame # Step Speed Start Stop
80 5 10 0 223
Subject #1 TD (200HZ)
Frame# 62
Ch1 Ch2 Ch3 Ch4 Ch5
Ch6
Ch5
ForcePlat...
Fy
Fz
-87.267
0.000
Fz: 542.960 Frame# 62
EMG/Muscle L...
TA/Muscle length
TA
33.620
1089.500
5.262
SOL/Muscle length
SOL
31.875
SOL: 36.526 Frame# 62


APASView 1.3
File
Window
Help
APASViewControl
Frame #
Step
Speed
Start
Stop
0
1
10
0
63
Step forward
bw2.avp
0: Rhtbr.3ld
AVIWindow
2: Gideon.ana
LHam
0.481
-0.505
LQuadMed
1.309
-1.217
RHam
1.479
0.940
RQuadMed
0.285
-0.292
Mz
3.764
-2.417
My
4.218
-0.044
Mx
0.456
-18.239
Fz
124.990
-0.053
Fy
28.452
-17.481
Fx
4.194
DX L.KNEE
-15.351
-55.553
DX R.KNEE
-20.291
-65.234
DX R.KNEE : -64.747 in Time 0.00
3: Apasview...
DX L.ANKLE
-23.899
-57.756
DX L.KNEE
-15.351
-55.553
DX L.HIP
-19.297
-61.897
DX R.HIP
-18.800
-63.098
DX R.KNEE
-20.291
-65.234
DX R.ANKLE
-20.444
-67.766
DX R.FOOT
5: Apasview.3d
6: Apasview.3d
Step forward

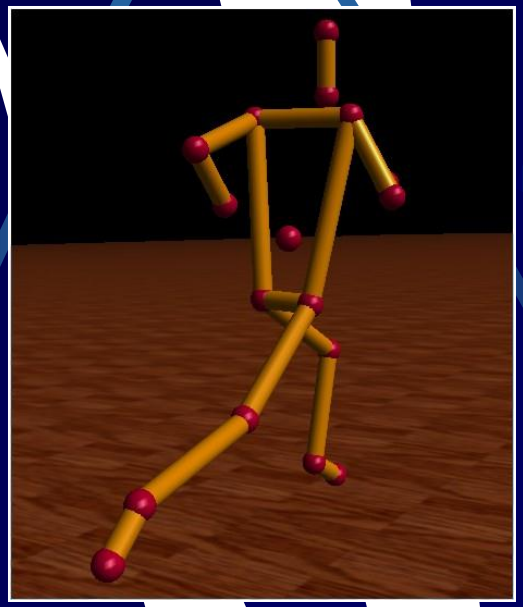

Window
Help
APASViewControl
Frame
Step
Speed
Start
Mv2p0.txt
Muscle Lenght
TA ML
34.828
33.218
TA EMG
1089.500
5.262
SOL ML
34.063
31.875
SOL EMG
532.310
SOL EMG: 9.428 Frame# 0
Raw EMG
ES
427.650
-281.500
RF
136.980
-99.006
VL
309.050
-177.650
BFCL
-347.070
SOL
-460.820
TA
505.240
-1089.500
TA: 43.370 Frame# 0
76
11
2
1
10
TA
SOL
BFCL
VL
RF
Moments.3
80.917
-90.751
55.847
-63.866
8.855
Muscle Length
VL ML
0.319
0.281
VL
309.050
2.738
RF ML
0.524
0.474
RF
169.690
0.883
BFCL ML
0.414
0.370
BFCL
347.070
Forceplate
Fx
159.260
-191.560
Fz
1102.900
Bone On Bone Forces
Bone/Bone force
4110.300
-114.570
Resulting Joint Forc
1101.900
7.589
Muscle Force TS
3183.500
-173.770
Moment arm SOL
5.575
4.361
Ankle Moment
8.855


APASView 1.3
Window
Help
APASViewControl
Frame #
Step
Speed
Start
Stop
Joint Force-
Joint angle-Left
Euler angle-Left
Joint Moment-
ForcePlate
Gait animation
Joint Force-
Joint Moment-Right
Ant/pos
Med/Lat
Prx/Dis
Hip Int/Ext
Hip Abd/Add
Hip Flx/Ext
Knee Int/Ext
Knee Abd/Add
Knee Flx/ext
Ankle Inv/Eve
Ankle Var/Val
Ankle Pla/Dor
Thigh psi
Thigh theta
Thigh phi
Calf psi
Calf theta
Calf phi
Foot psi
Foot theta
Foot phi
FZ2
FZ-1
FX-1: -0.004 Nt Time 0.00
Prx/Dis: -3.182 N Frame# 0
Dor: 0.844 Nm Frame# 0
Prx/Dis: -2.808 N Frame# 0
Ankle Pla/Dor: 12.353 Frame# 0
Foot phi: -0.223 rad Frame# 0
Ankle Pla/Dor: 0.174 Nm Frame# 0

Real-time rendering

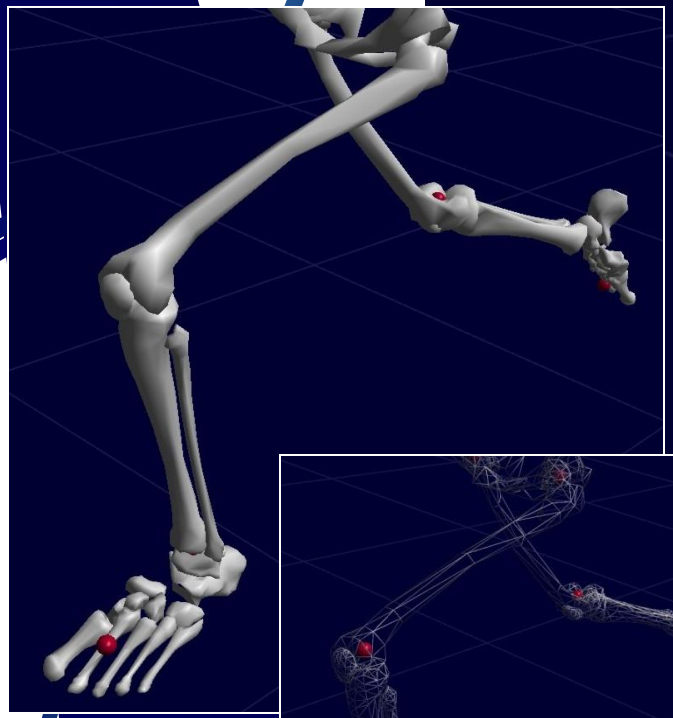


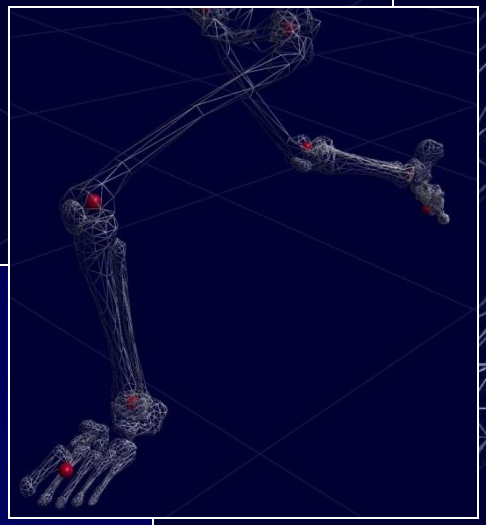
Traditional stick figure



Real-time rendering

What is Rendering anyway?



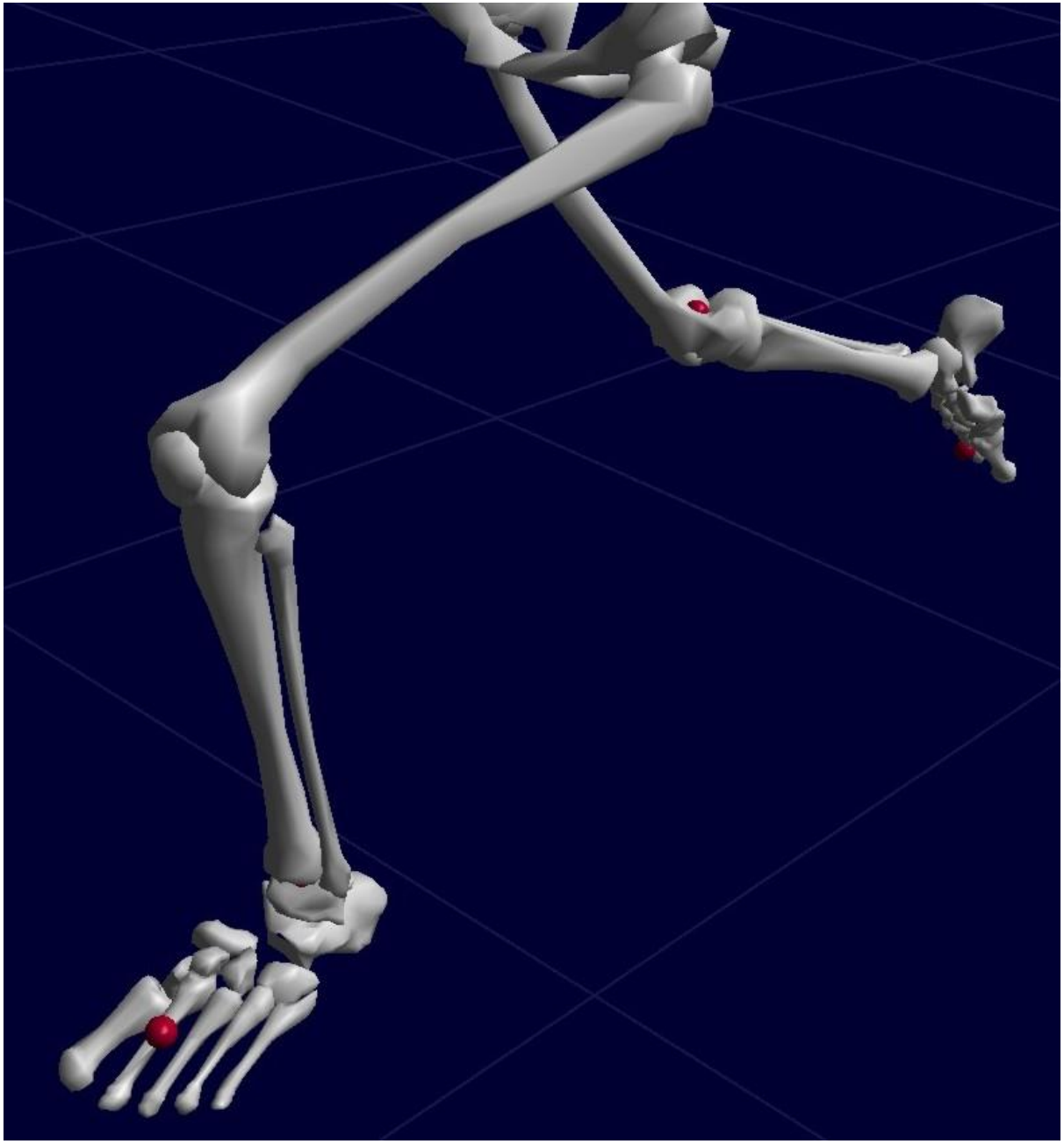


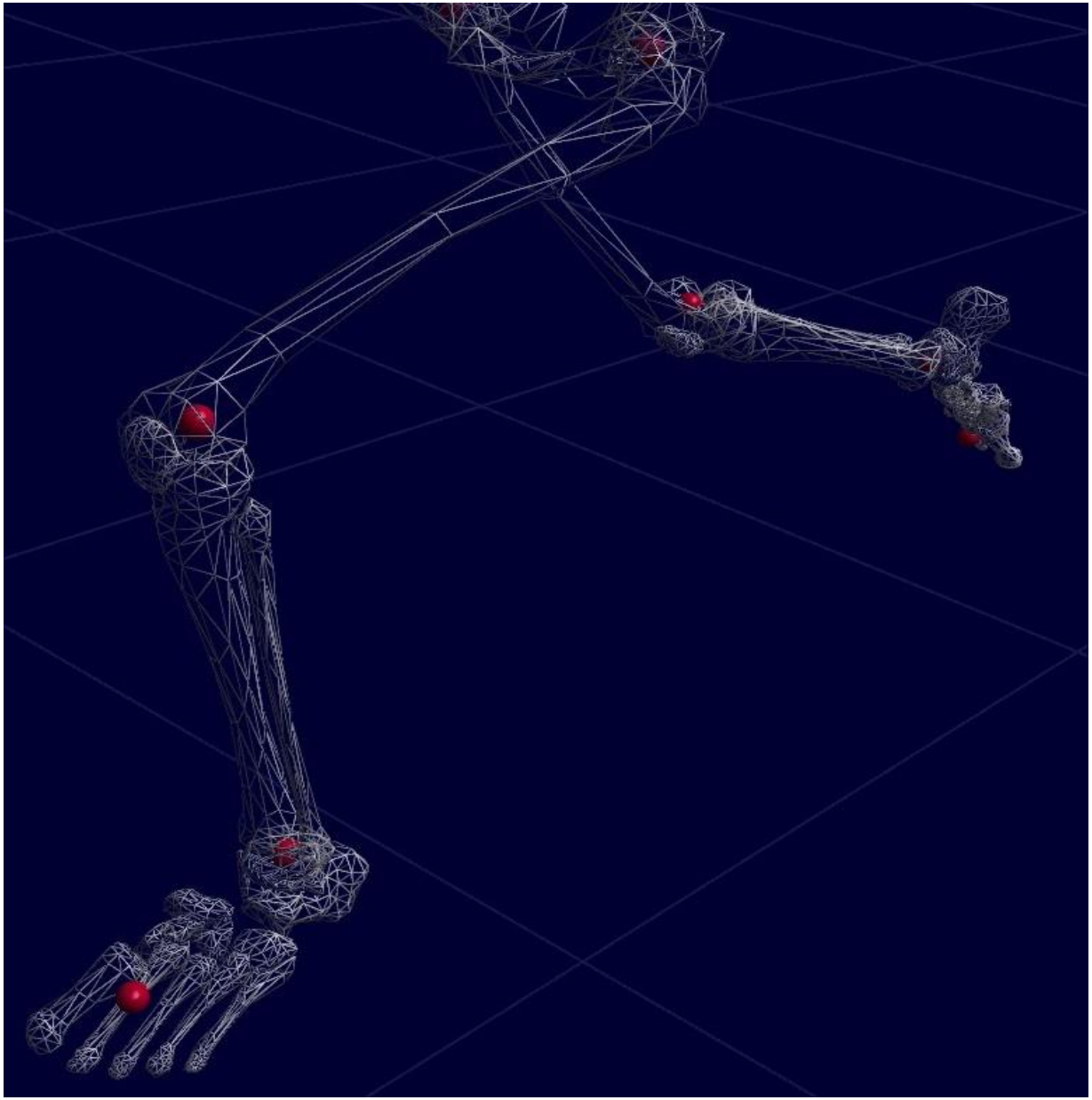
Definition of:

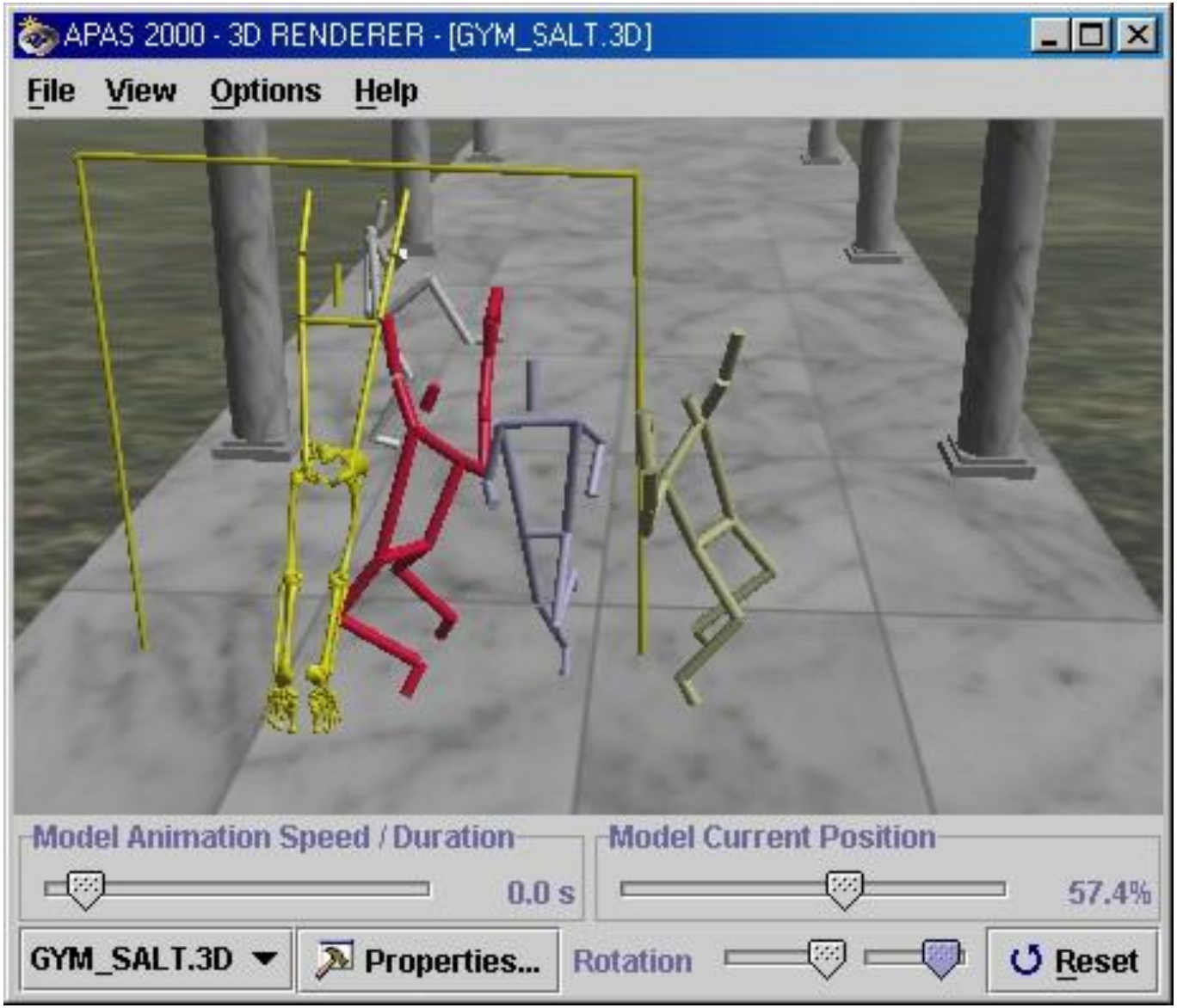
- Graphic objects
- Lighting
- Environmental effects
- Behavior
- Physical characteristics

Calculate views:

- Computer screens
- Immersive workbench
- Head-tracked glasses



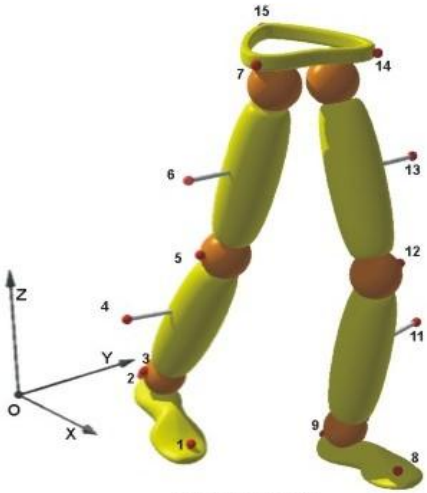



APAS 2000 - 3D RENDERER - [GYM_SALT.3D]
File
View
Options
Help
Model Animation Speed / Duration
0.0 s
Model Current Position
57.4%
GYM_SALT.3D
Properties...
Rotation
Reset

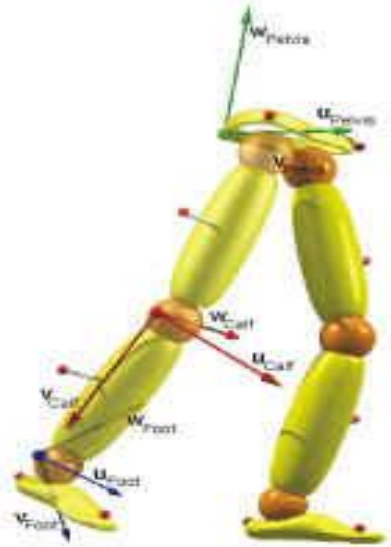
Video Clip

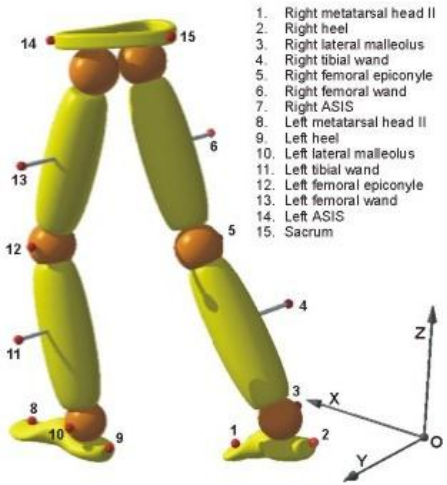
Gait Analysis with Markers Sets

sungait.htm



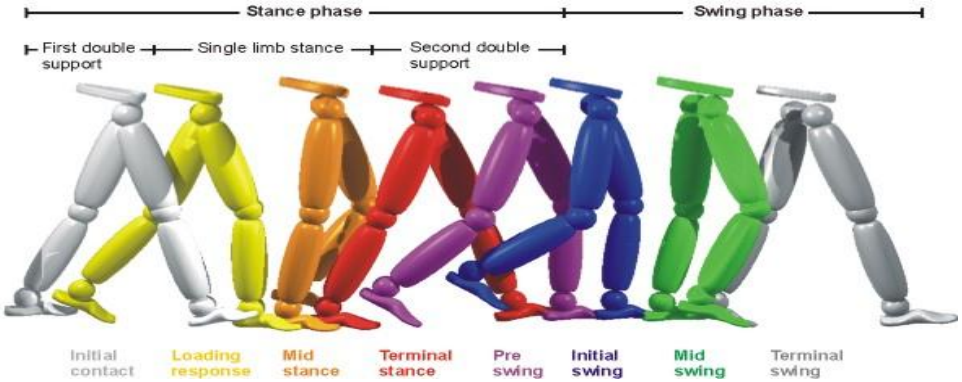
(A) Anterior View

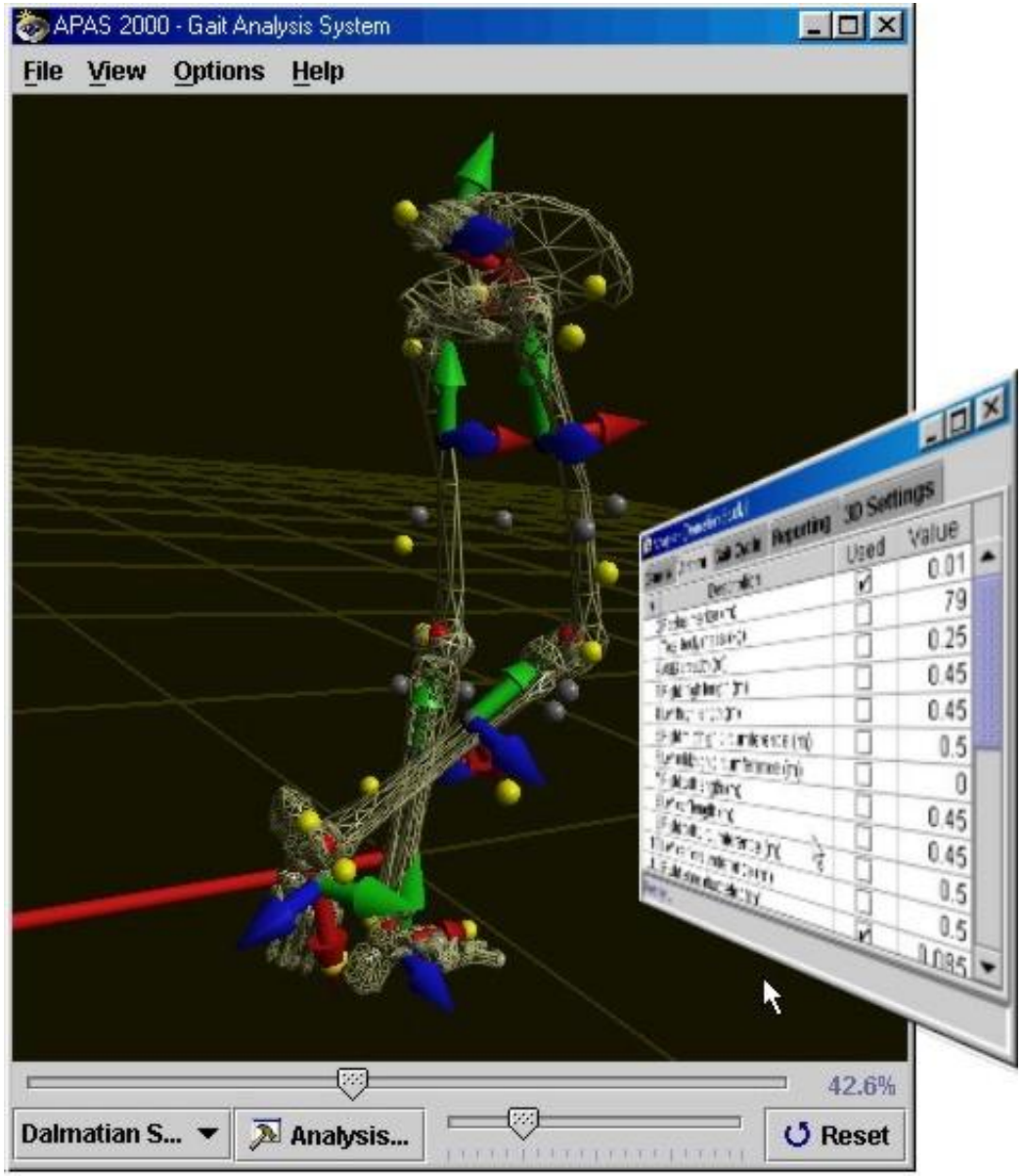


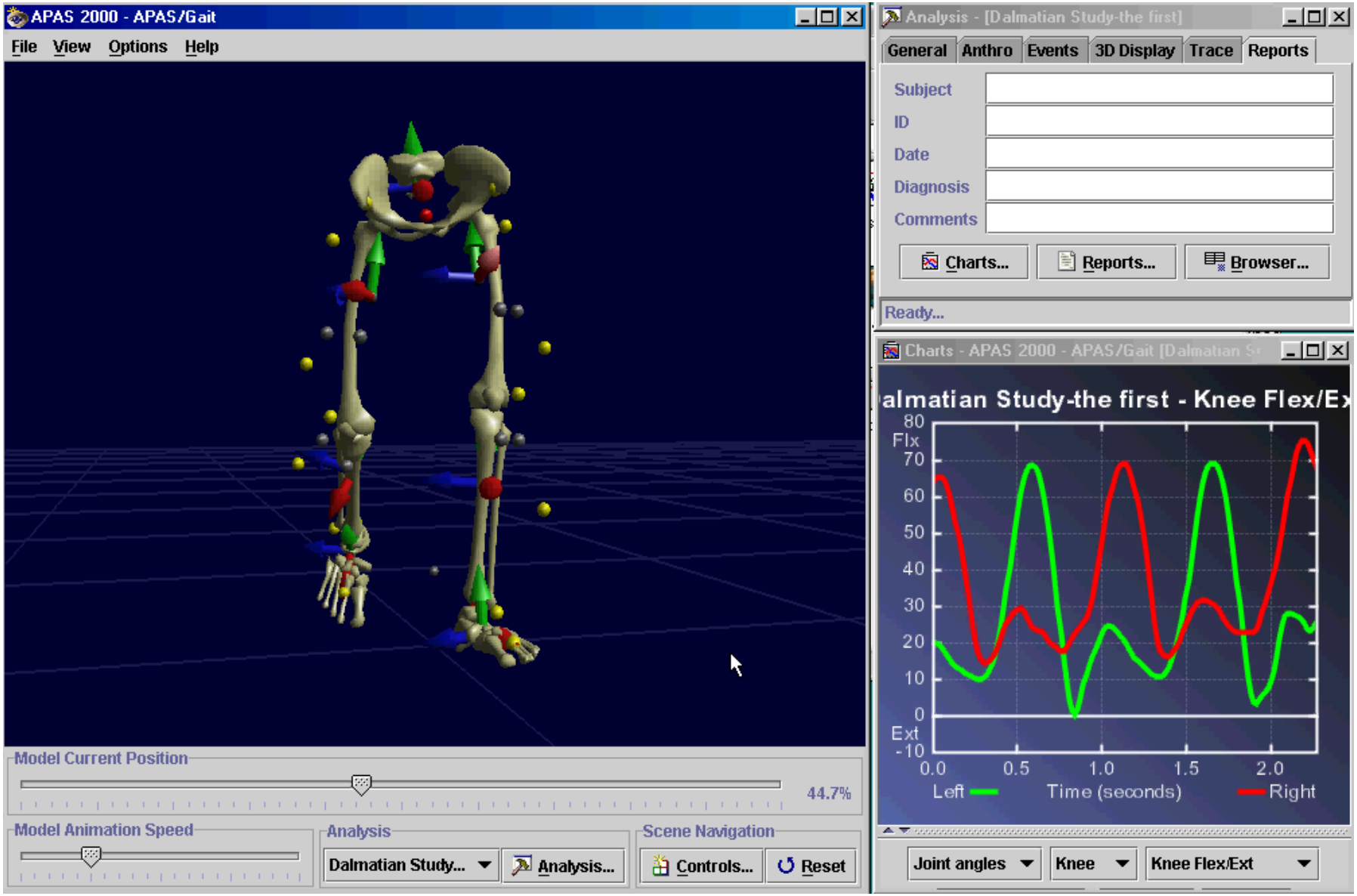


1. Right metatarsal head II
2. Right heel
3. Right lateral malleolus
4. Right tibial wand
5. Right femoral epiconyle
6. Right femoral wand
7. Right ASIS
8. Left metatarsal head II
9. Left heel
10. Left lateral malleolus
11. Left tibial wand
12. Left femoral epiconyle
13. Left femoral wand
14. Left ASIS
15. Sacrum

(B) Posterior View




APAS 2000 - Gait Analysis System
File
View
Options
Help
Reporting
3D Settings
Used
Value
0.01
79
0.25
0.45
0.45
0.5
0
0.45
0.45
0.5
0.5
42.6%
Dalmatian S...
Analysis...
Reset

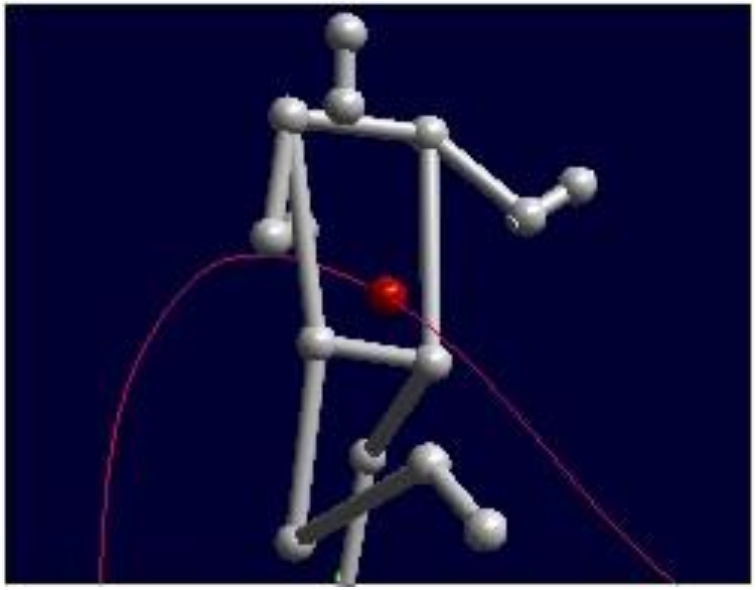

APAS 2000 - APAS/Gait
File View Options Help
Model Current Position
44.7%
Model Animation Speed
Analysis
Dalmatian Study...
Analysis...
Scene Navigation
Controls...
Reset
Analysis - [Dalmatian Study-the first]
General Anthro Events 3D Display Trace Reports
Subject
ID
Date
Diagnosis
Comments
Charts...
Reports...
Browser...
Ready...
Charts - APAS 2000 - APAS/Gait [Dalmatian S
almatian Study-the first - Knee Flex/Ex
80
Flx
70
60
50
40
30
20
10
0
Ext
-10
0.0
0.5
1.0
1.5
2.0
Left
Time (seconds)
Right
Joint angles
Knee
Knee Flex/Ext

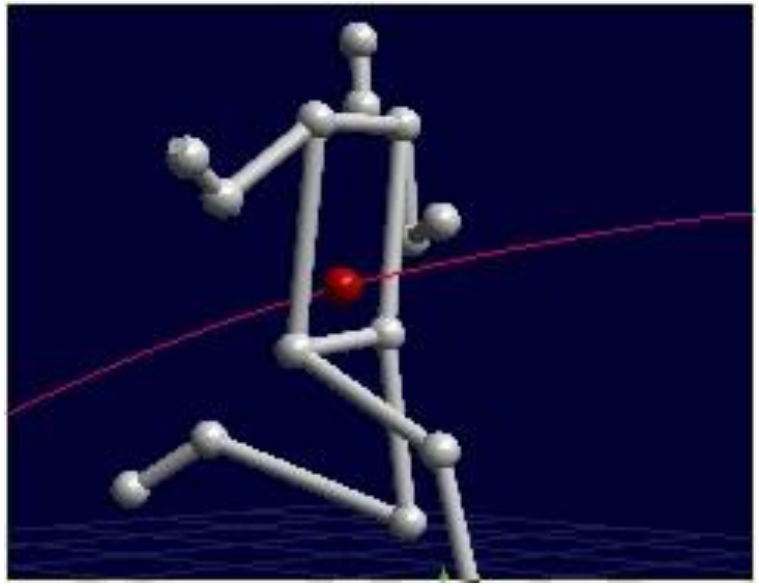
The Future – The Virtual ISBS

- Virtual Biomechanic Desk
  - Locate and download your favorite Biomechanical Data from one convenient, easy-to-use interface.
  - Software that allows users to share Biomechanical libraries with each other no matter where they are located. Virtual Biomechanics provides a search capability for videos, 3D/2D Files capability for users to communicate in forums of like interest.
  - Each Biomechanist is a download/upload source
  - Each User Computer, when it is on, it becomes a shared directory
  - For more information: http://www.arielnet.com

Virtual Biomechanics

Default.htm





The Future

- A user records and stores Video file in a specific folder on his or her hard disk
- A central directory maintained by Biomechanics.com keeps track of which users are logged on, cataloging by title and researcher/biomechanist the activity in each user's special folder
- A user searches through the Biomechanics.com directory for a desired activity or sports. Once the activity is downloaded it can be used for further analysis or observation. This file can also be sent to another person as e-mail or attachment
- Any user folder can be shared with the rest of the World
- Biomechanics.com monitor and publish the catalogue of activities and sports world wide

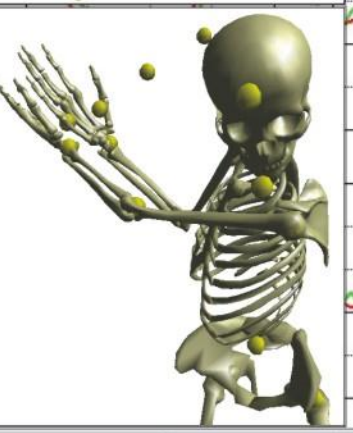
e-Golf

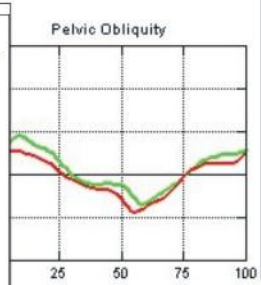
Reports - APAS 2000 - APAS/Gait [Dalmatian Study]

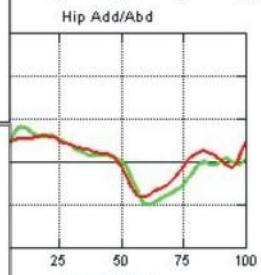
E-Golf Progress Report - John Doe

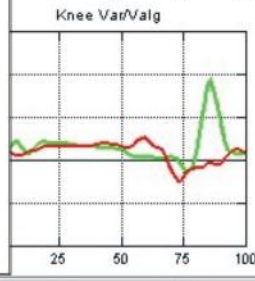
Trial Information	
Description:	Dalmatian Study
File:	GAITDEMO1.3D
Subject:	Rudolf J.C. Buijs
ID:	156151
Date:	April 15, 2000
Diagnosis:	[normal]
Comments:	APAS/Gait demo

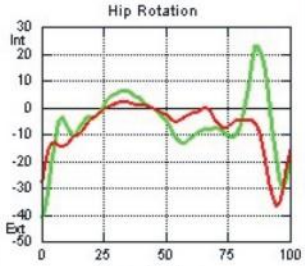
Gait Cycle Parameters	Left	Right
Loading Response (%)	11.11	9.46
Single Stance (%)	43.05	37.83
Unloading Response (%)	8.33	10.81
Swing (%)	37.5	41.89
Stride Duration (s)	1.23	1.23
Step Duration (s)	0.65	0.65
Cadence (Steps/min)	97.29	97.29

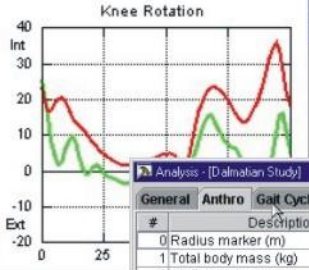












Joint angles | Gait Cycle | Print... | Close

Analysis - [Dalmatian Study]

General | Anthro | Gait Cycle | Reporting | 3D Settings

☑ Joint Centers ☐ Markers ☐ Local CS

Smooth Shaded Skeleton | Solid

Translate in X

Rotate around Y

Translate in Z

Ready...

Analysis - [Dalmatian Study]

General | Anthro | Gait Cycle | Reporting | 3D Settings

#	Description	Used	Value
0	Radius marker (m)	☑	0.01
1	Total body mass (kg)	☐	75
2	ASIS breadth (m)	☐	0.25
3	Right thigh length (m)	☐	0.45
4	Left thigh length (m)	☐	0.45
5	Right midthigh circumference (m)	☐	0.5
6	Left midthigh circumference (m)	☐	0.5
7	Right calf length (m)	☐	0.45
8	Left calf length (m)	☐	0.45

Overview - Microsoft Internet Explorer

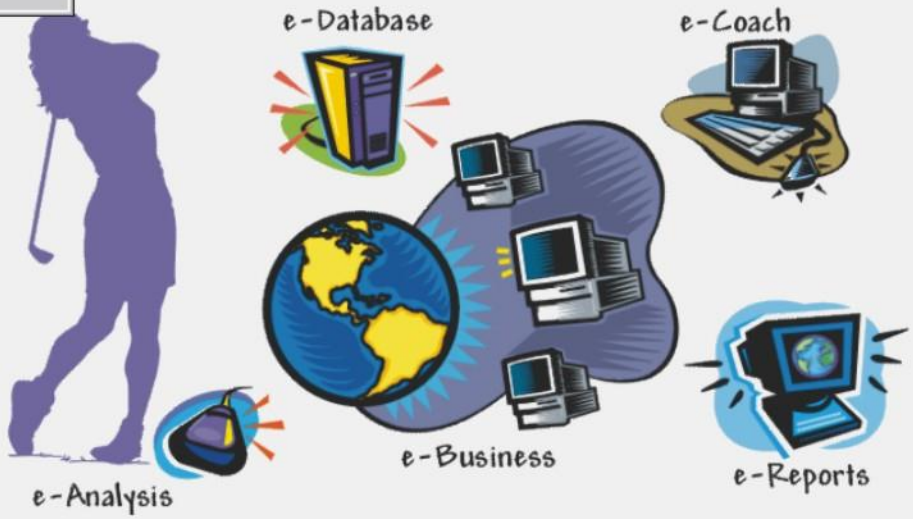
Edit View Favorites Tools Help

http://rudeness/ETR/concept/ETR-Tech-Concepts.htm

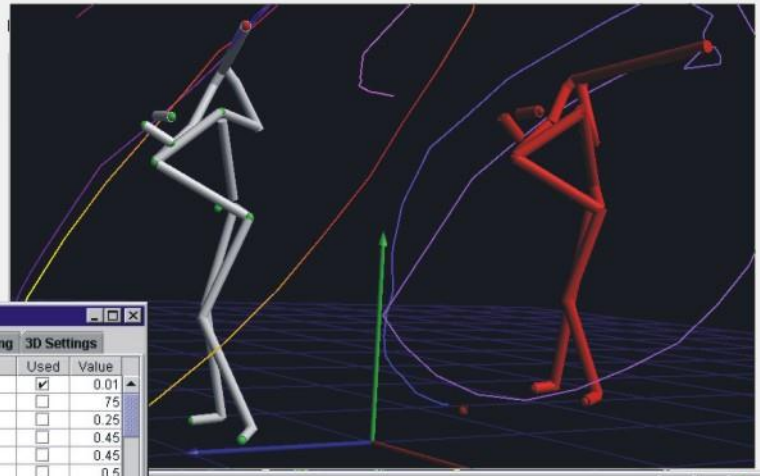
system that will be installed at driving ranges and golf courses.

of the system is a motion capture system: it allows a golfer to step in, simply touch a button on the screen and then begin After the motion capture, this data will be analyzed. Analysis will be performed by a combination of automatic nical analysis and interactive contact with virtual golf trainers (e-Coach). Analysis results will be available from any browser how the user what he's done wrong. He can compare himself to other golfers of a slightly better handicap or a professional r and easily analyze his mistakes.

ally, the system will have the following components:



The e-Golf Reports (or e-Reports) will be one of the most important technical factors of the system. With these reports, users should be able to understand their mistakes. Users will be able to improve their skills by interacting with e-Coaches, keeping records of progress, get on-line update recommendations for training, design training programs, obtain third party intervention, track progress and learn online through real-time interaction.



Local intranet

THANK YOU