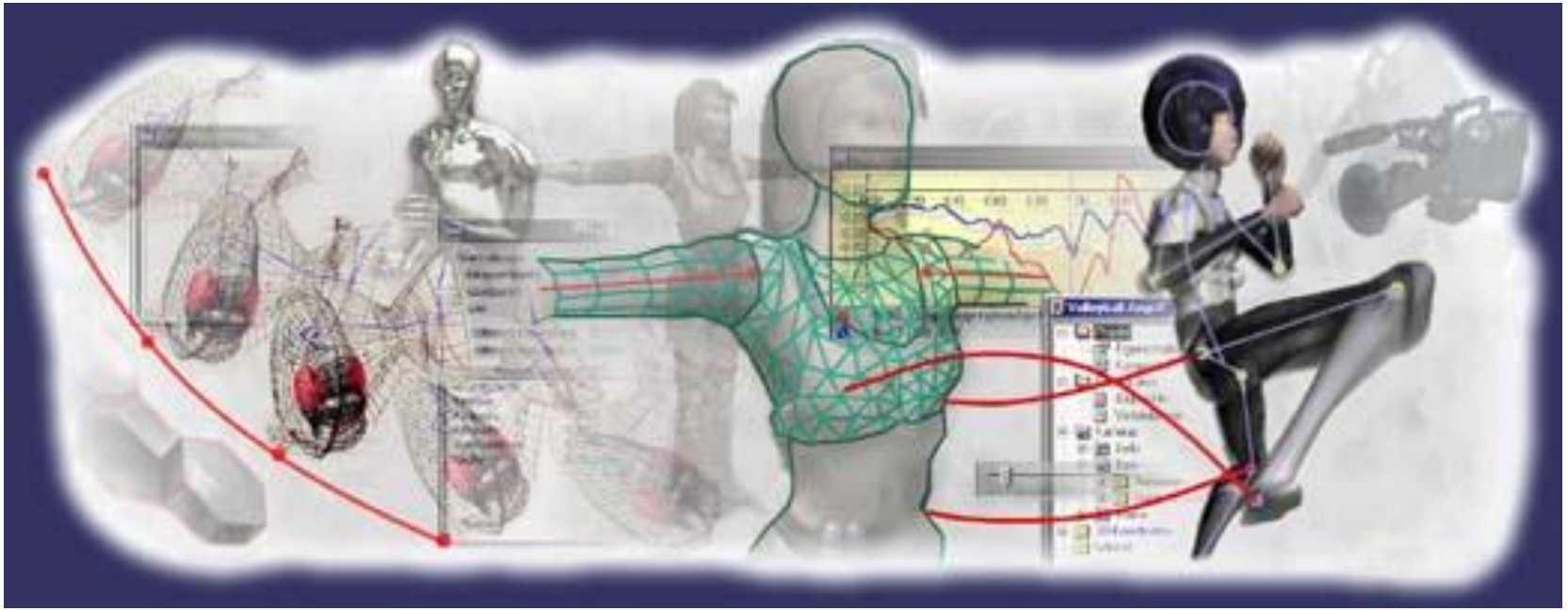
Optimizing Performance Through High-Tech and Internet Science



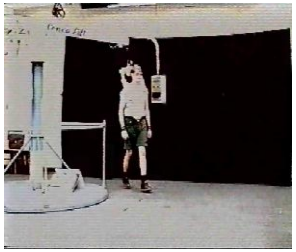
By Gideon Ariel, Ph.D.

XV International Athletics Coaches Congress

World Championships, Edmonton, Canada 2001

MOVEMENT ANALYSIS CAN BE APPLIED TO:

Athletics

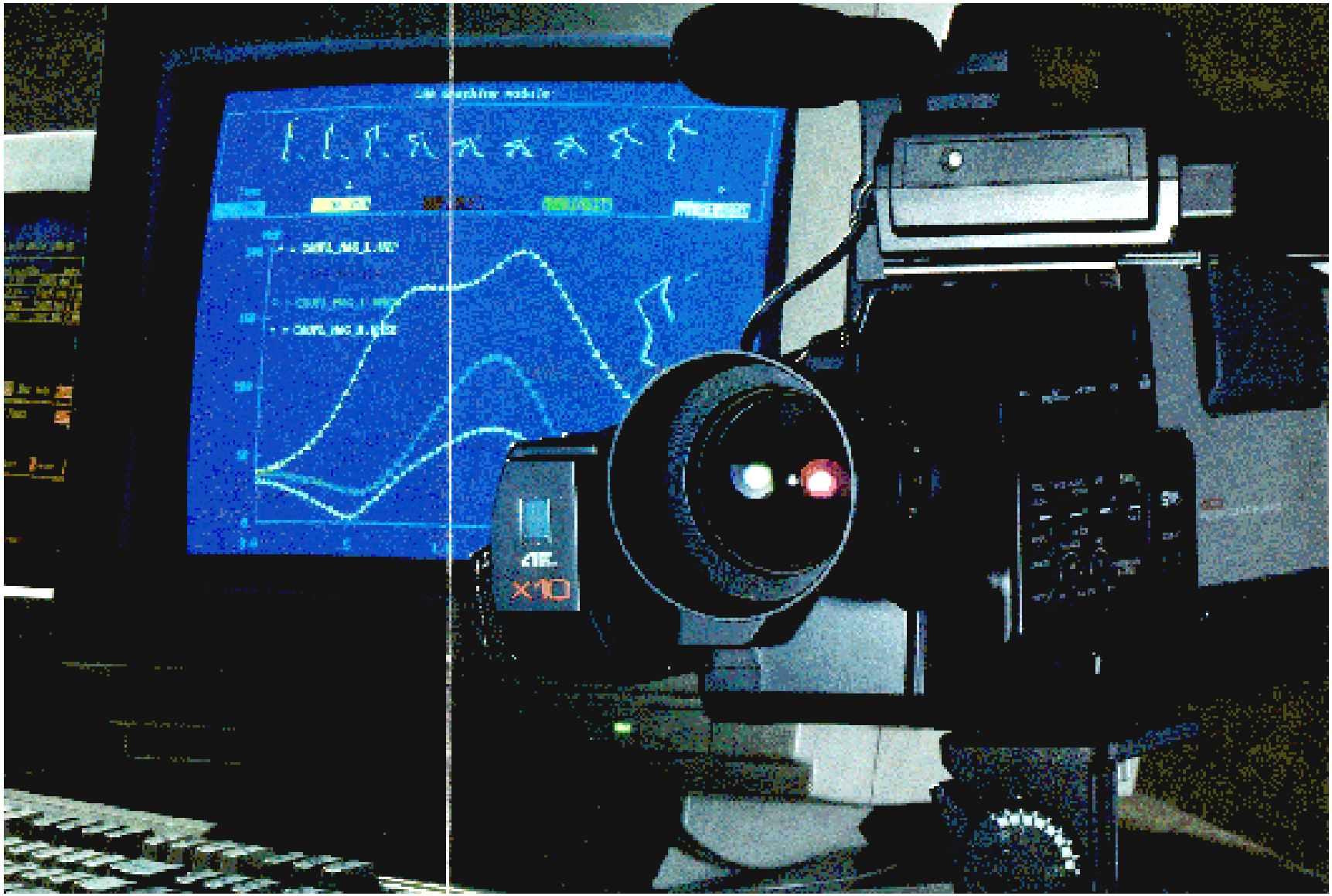


Industry

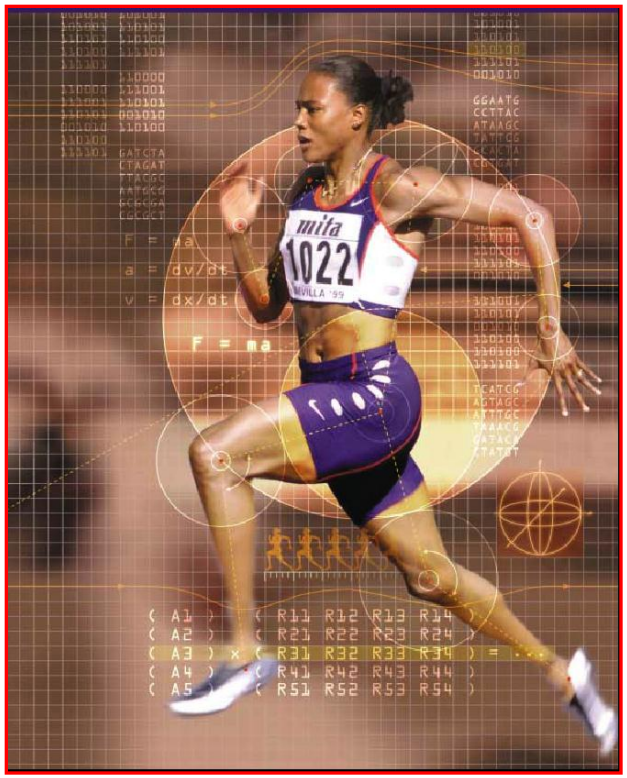
Medicine

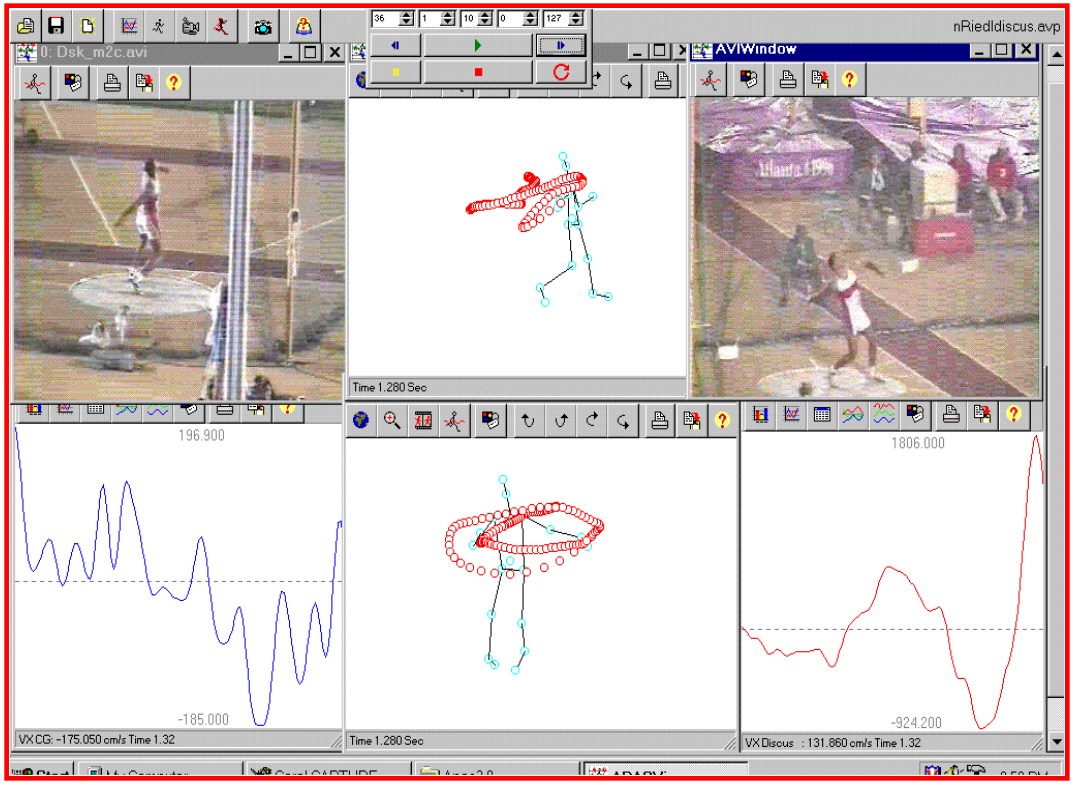
Space

ALL APPLICATIONS UTILIZED SIMILAR QUANTIFICATION TECHNIQUES

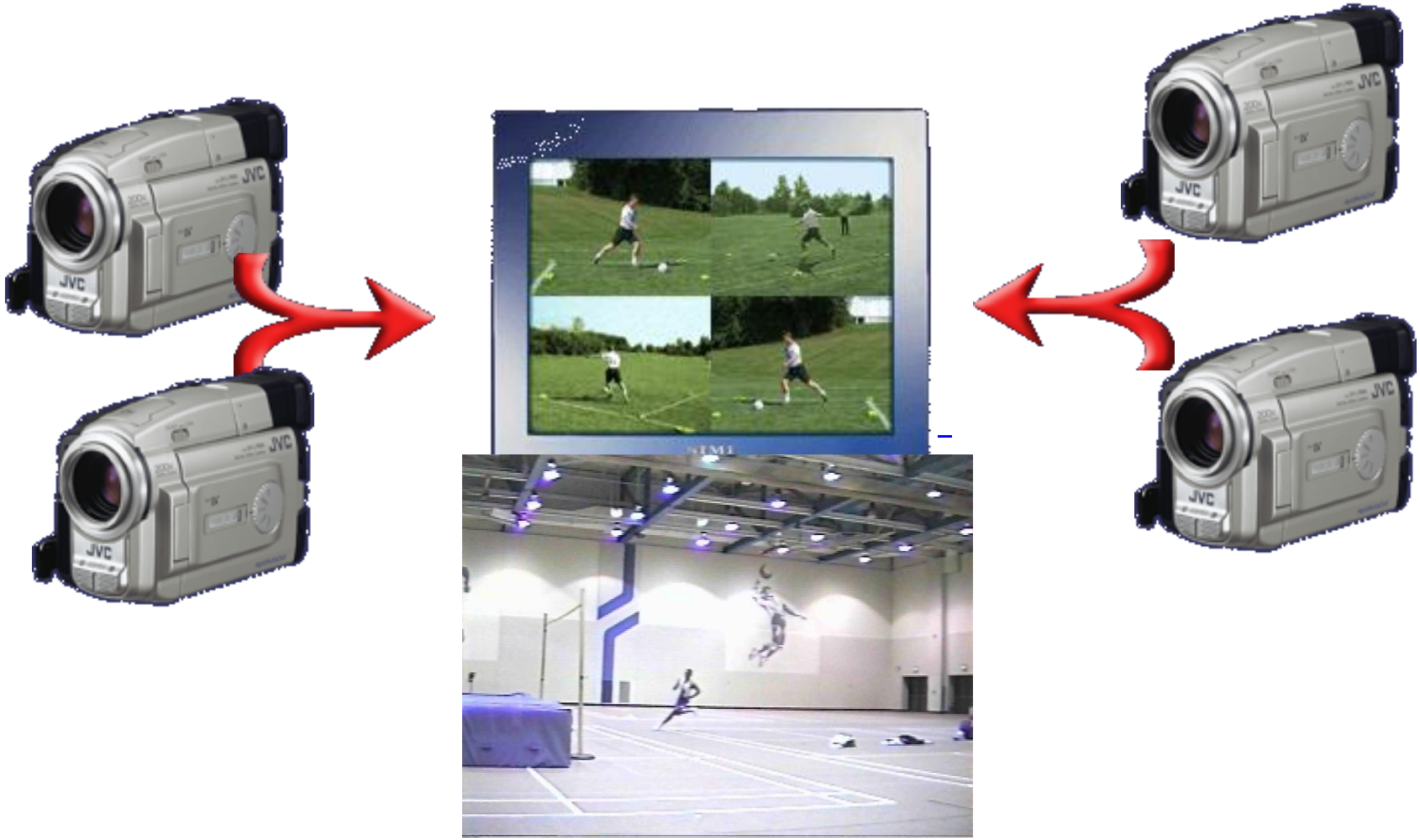


Captures Movement in Three-Dimensional Space

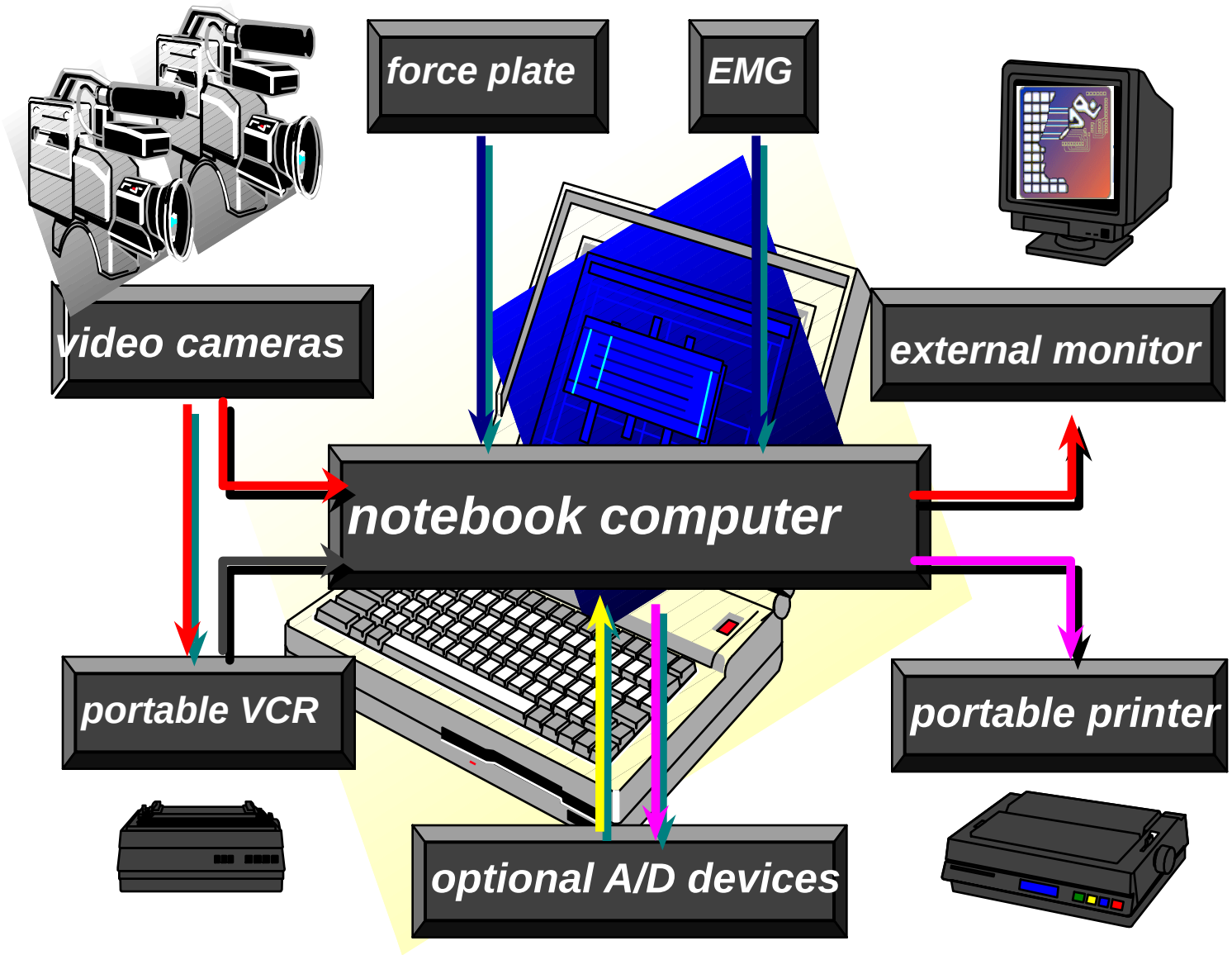




Capture videos using several cameras simultaneously and save the clips directly as AVI files to your hard disk. This allows you to connect multiple digital video cameras to your computer and to start capturing with one mouse click.



Basic Components of Motion Analysis System



Analysis of Performance Requires:

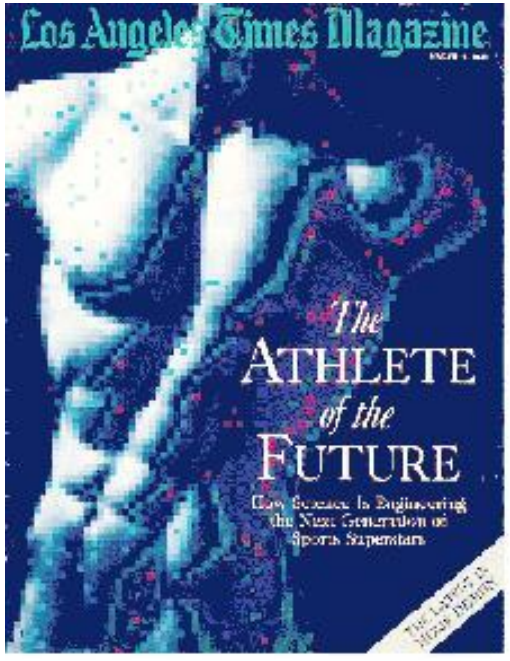
Video Recording

Digitizing the Data

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

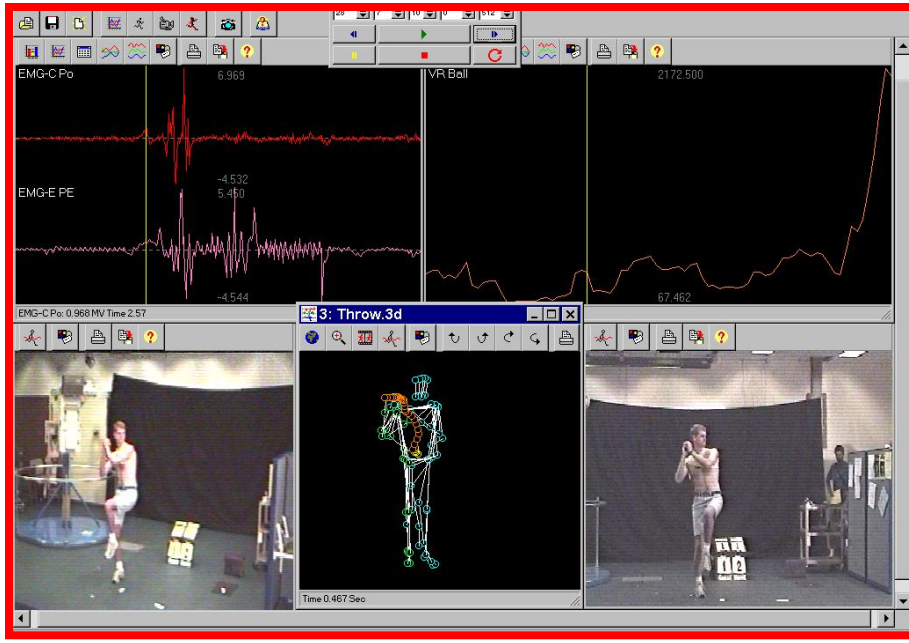
Transformation of the Data

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



Hardware

- Main Computer System
- Workstations
- High Speed Camera
- Capture Card
- Network
  - Intranet
  - Internet



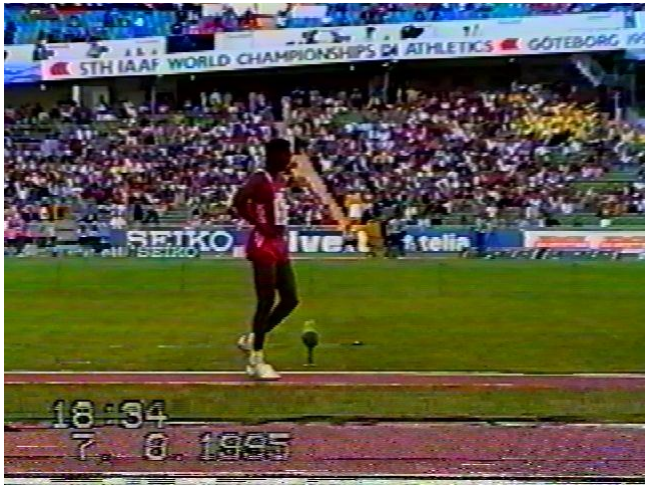
High Speed Camera at 240 Hz

Video Capturing System

Video Capturing Software Packages

Video Recording

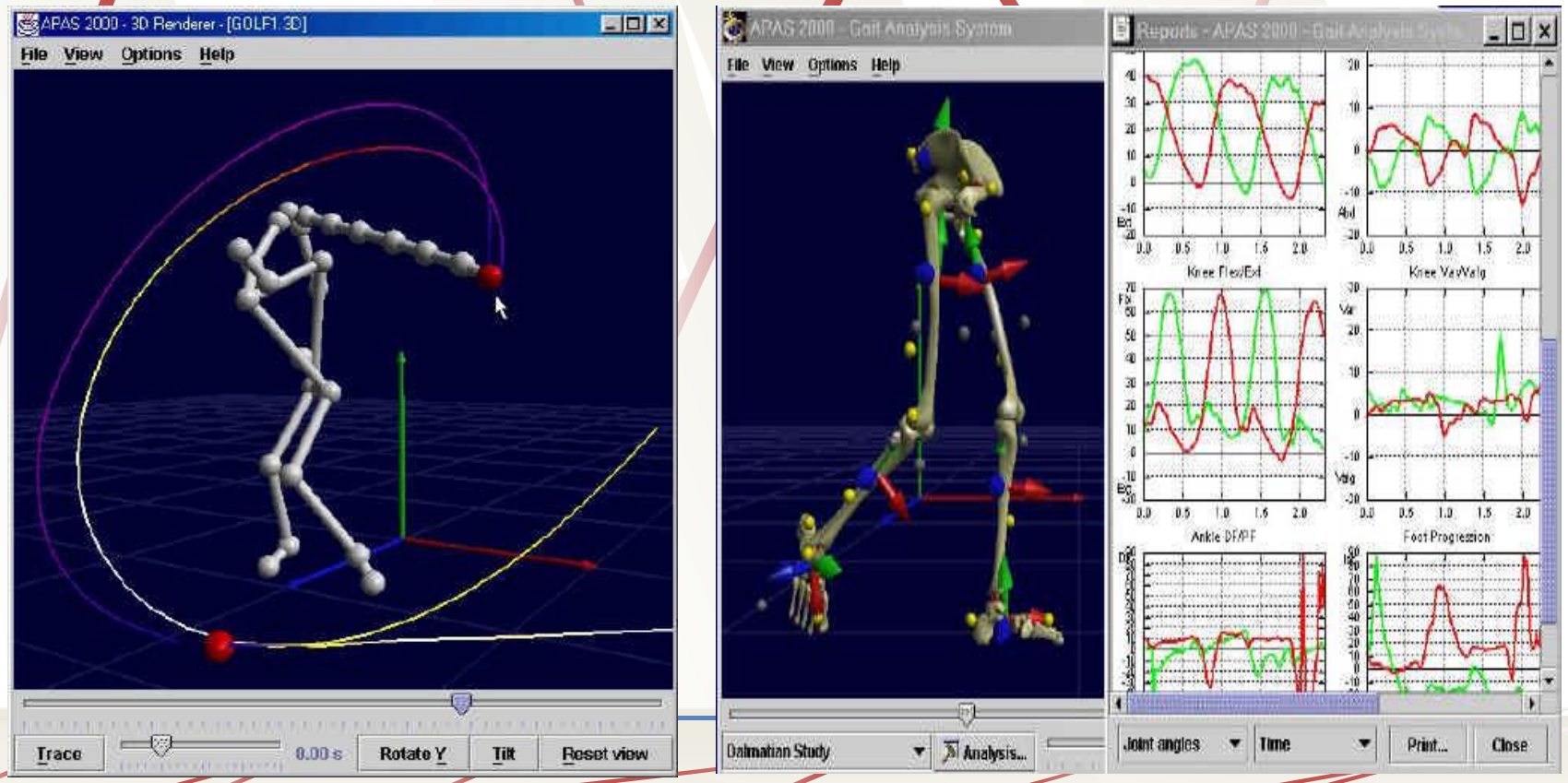
Video Capturing



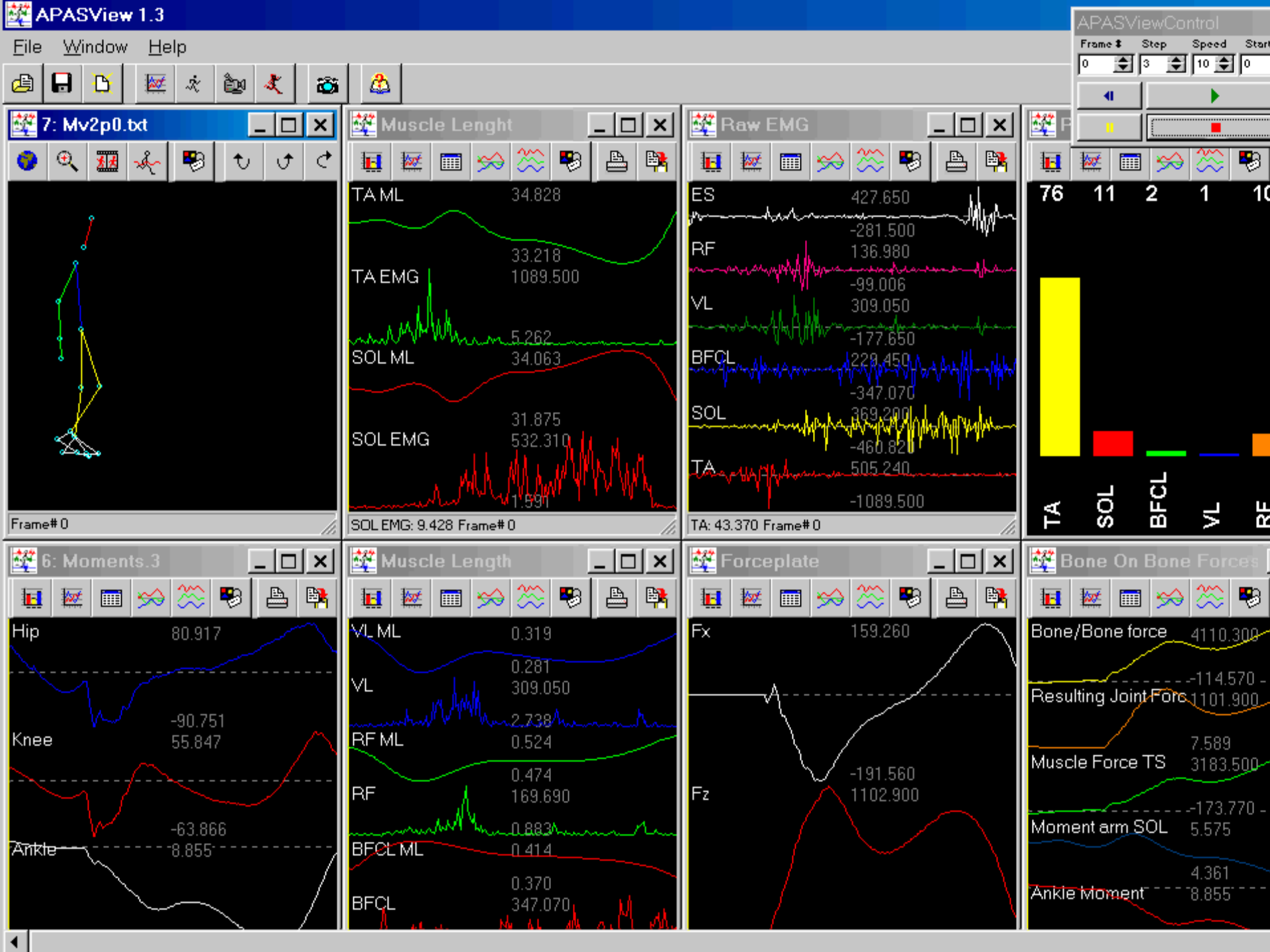
The world record in triple jump of 18.29m by J. Edwards, UK

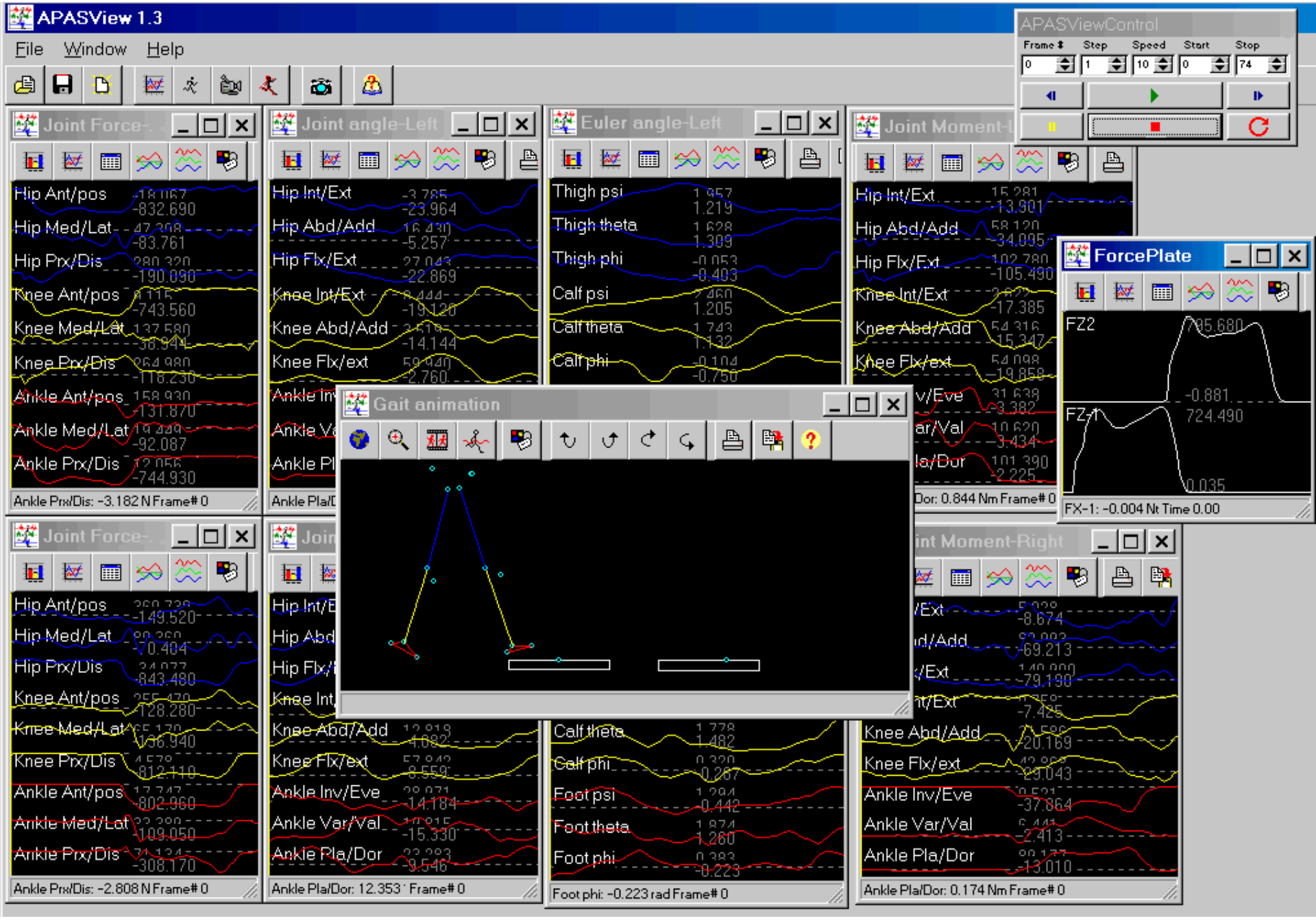
Reidel Gold Medal

Software Integration



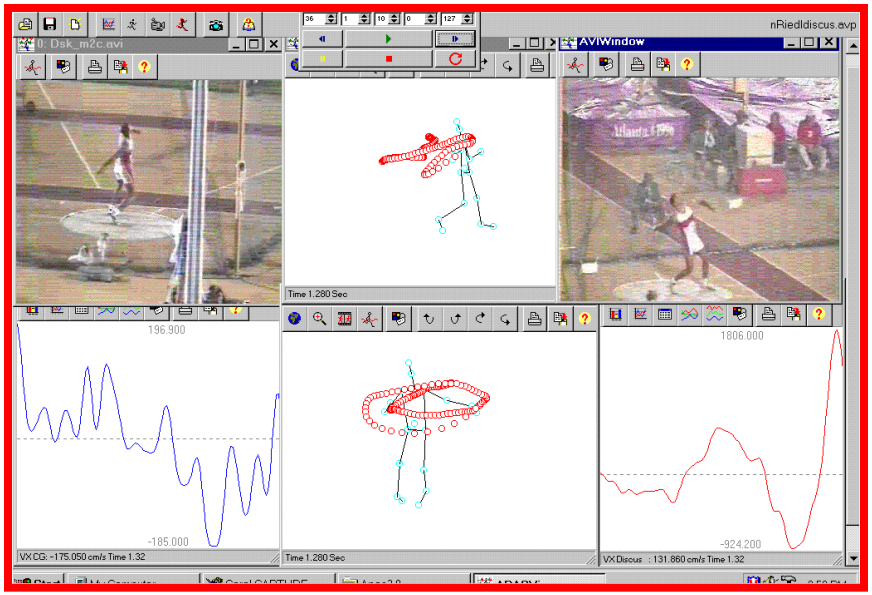

APASView 1.3
File Window Help
APASViewControl
Frame # Step Speed Start Stop
0 1 10 0 63
Step forward
0: Rhtbr.3ld
AVIWindow
2: Gideon.ana
LHam 0.481
-0.505
LQuadMed 1.309
-1.217
RHam
0.940
RQuadMed 0.285
-0.292
Mz
-2.417
My 4.218
-0.044
Mx 0.456
-18.239
Fz
-0.053
Fy 28.452
-17.481
Fx 4.194
DX L.KNEE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


APASView 1.3
File
Window
Help
APASViewControl
Frame #
Step
Speed
Start
7: Mv2p0.txt
Frame# 0
Muscle Lenght
TA ML
34.828
33.218
TA EMG
1089.500
5.262
SOL ML
34.063
31.875
SOL EMG
532.310
1.591
SOL EMG: 9.428 Frame# 0
Raw EMG
ES
427.650
-281.500
RF
136.980
-99.006
VL
309.050
-177.650
BFCL
229.450
-347.070
SOL
369.200
-460.820
TA
505.240
-1089.500
TA: 43.370 Frame# 0
76
11
2
1
TA
SOL
BFCL
VL
6: Moments.3
Hip
80.917
-90.751
Knee
55.847
-63.866
Ankle
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

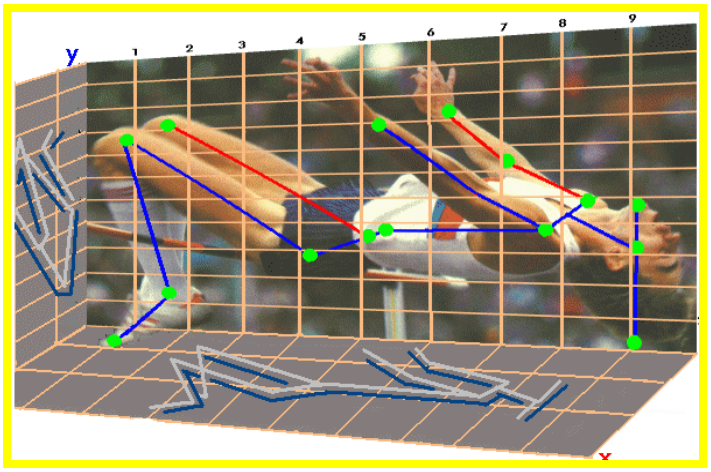

APASView 1.3
File
Window
Help
APASViewControl
Frame #
Step
Speed
Start
Stop
Joint Force-
Hip Ant/pos
Hip Med/Lat
Hip Prx/Dis
Knee Ant/pos
Knee Med/Lat
Knee Prx/Dis
Ankle Ant/pos
Ankle Med/Lat
Ankle Prx/Dis
Ankle Prx/Dis: -3.182 N Frame# 0
Joint angle-Left
Hip Int/Ext
Hip Abd/Add
Hip Flx/Ext
Knee Int/Ext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

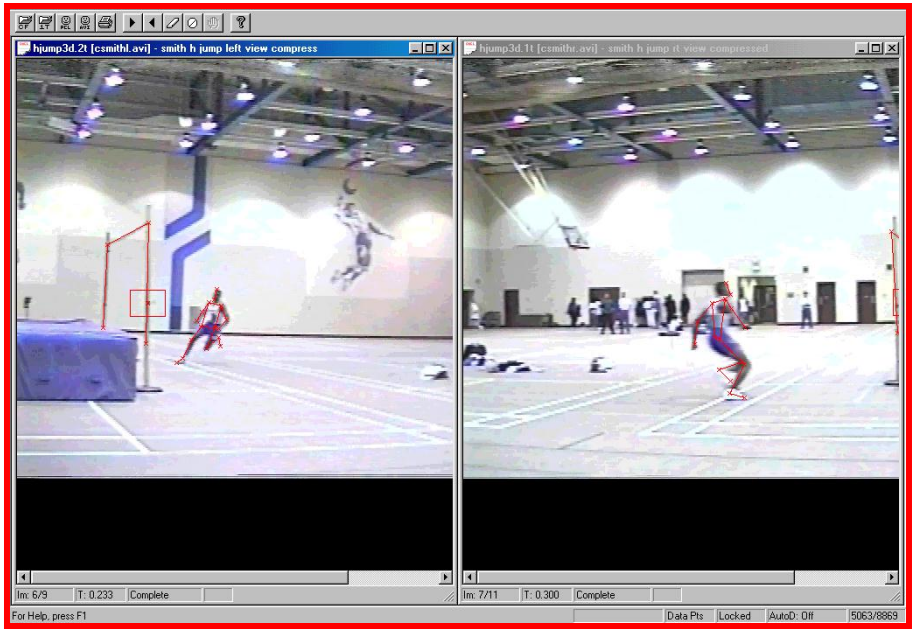
Software Integration

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



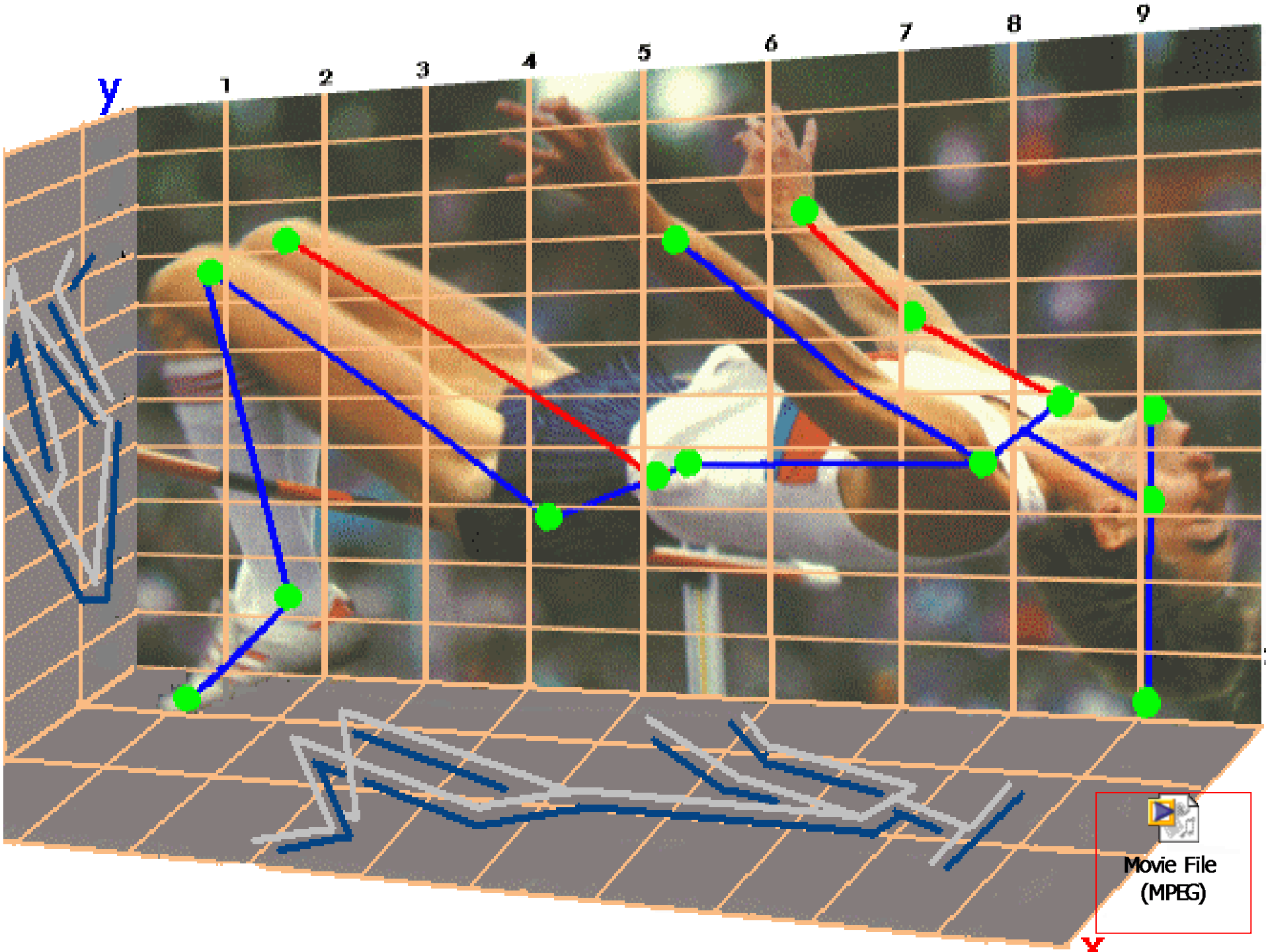
Digitizing


y
1
2
3
4
5
6
7
8
9
x

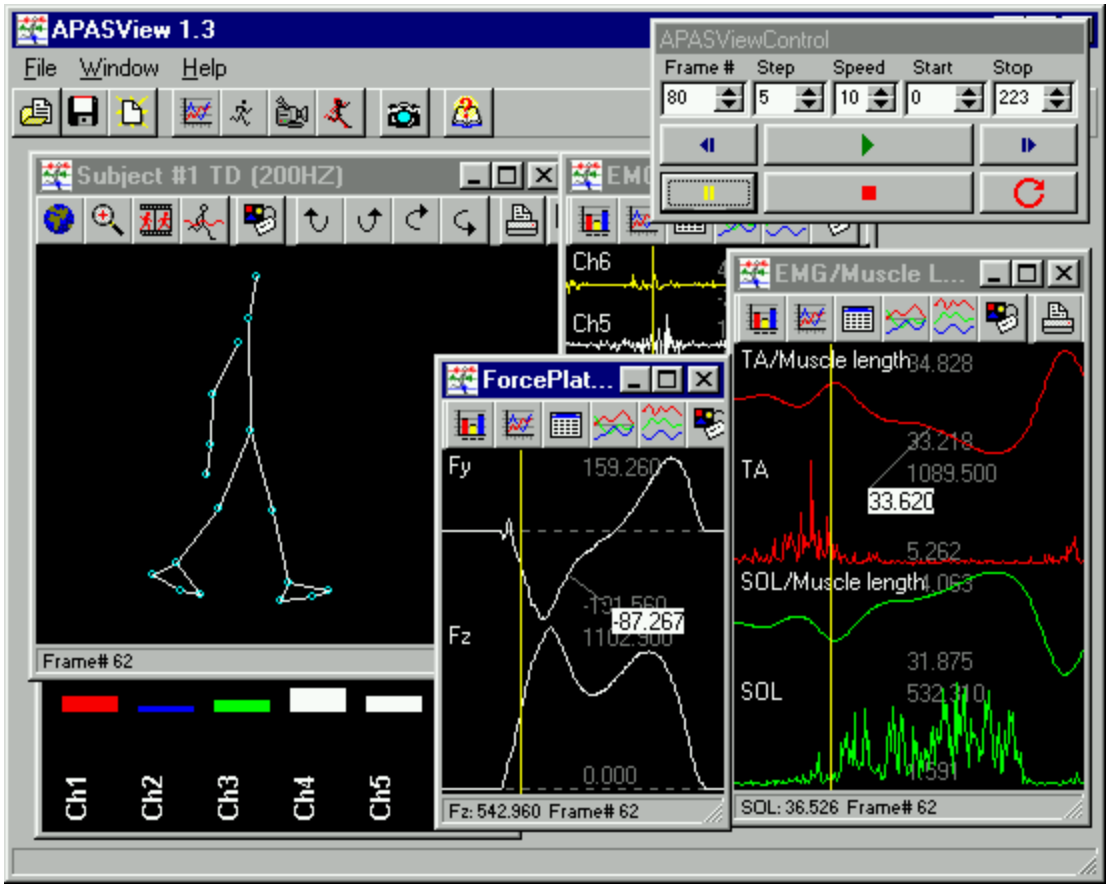

hjump3d.2t [csmithl.avi] - smith h jump left view compress
hjump3d.1t [csmithr.avi] - smith h jump rt view compressed
Im: 6/9
T: 0.233
Complete
Im: 7/11
T: 0.300
Complete
For Help, press F1
Data Pts
Locked
AutoD: Off
5063/8869

Digitizing

- Manually
- Automatically

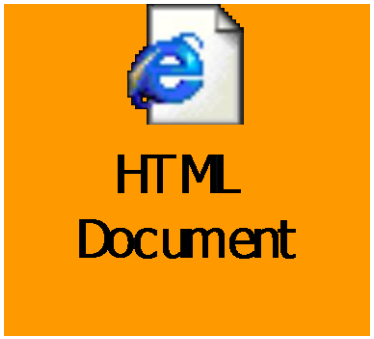

y
1
2
3
4
5
6
7
8
9
Movie File
(MPEG)

Display and Analysis



Displaywin.exe

The world record in triple jump of 18.29m by J. Edwards, UK

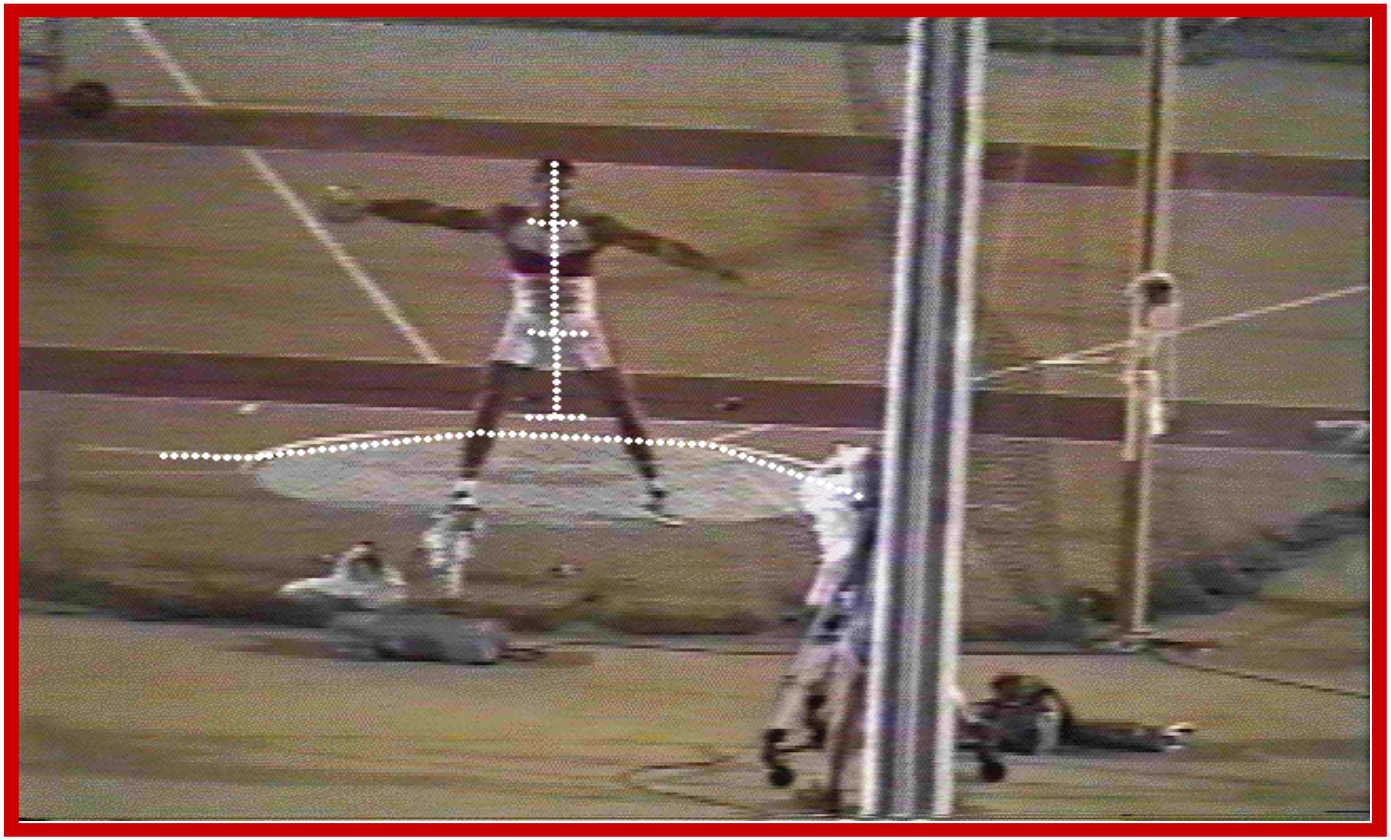



Atlanta 1996

Camera Views

21 data points were digitized and transformed to real distances and smoothed at 10 Hz frequency cut-off with an second order Butterworth digital filter.

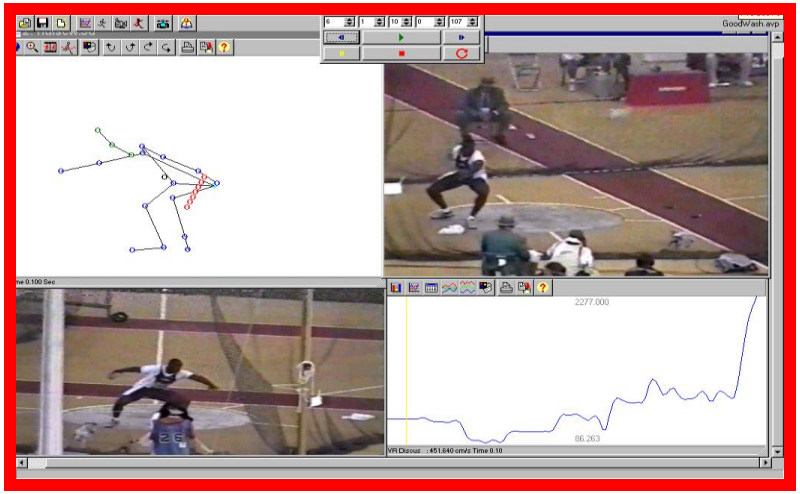
Calibration Cube

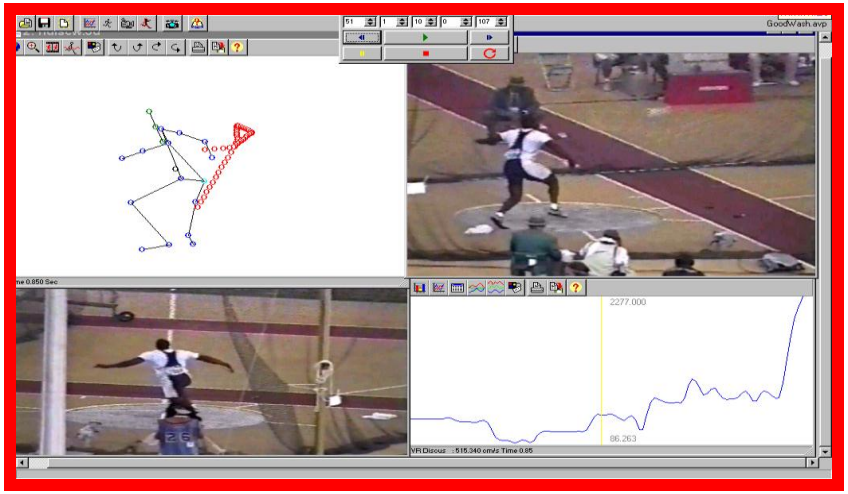


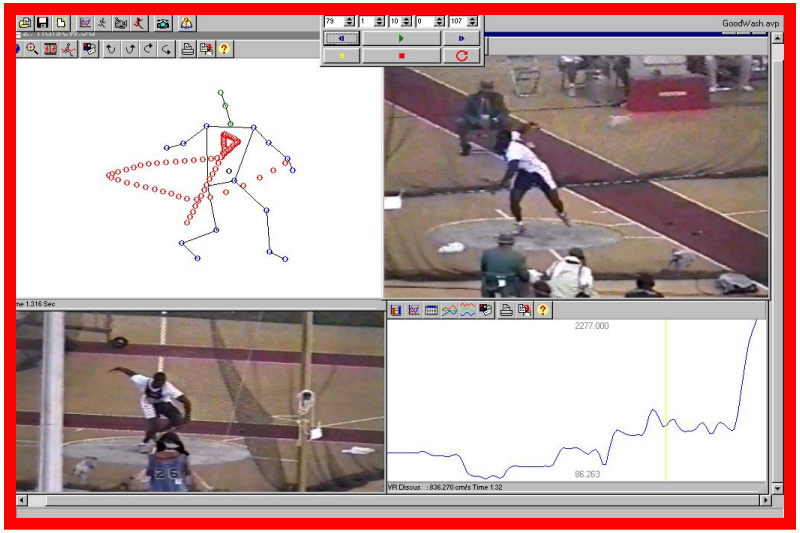
Washington Throwing Kinematics

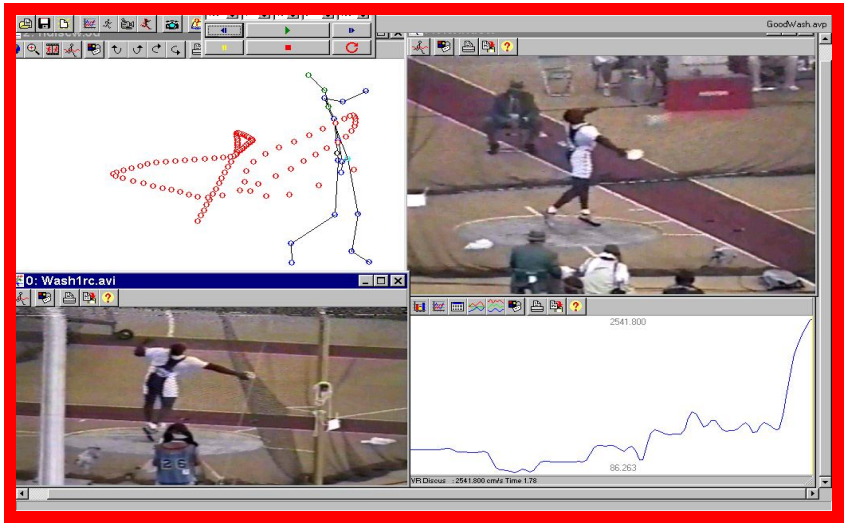
Attempt	Distance m.	Velocity $cm \bullet sec^{-1}$	Projection Angle rad (deg)	Release HT cm	Move Time sec
Best Throw	65.4	2541V_r 2134 V_x	.52 (29.9)	120	1.2
Worst Throw	61.3	2441 V_r 1222 V_x	1.05 (59.9)	140	1.4
% Change	-6.3%	-4.0% V_r -43.0% V_x	+100%	+17%	+12%

Discus APAS view
Data Integration









Enter Root Filename [8 Chars]
Filename:washcom4

Enter-Select
VIEWING Module C.B.A. Inc.

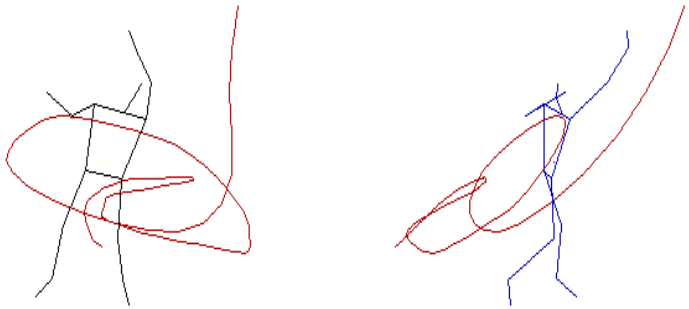
Washington Best Throw

Y
X

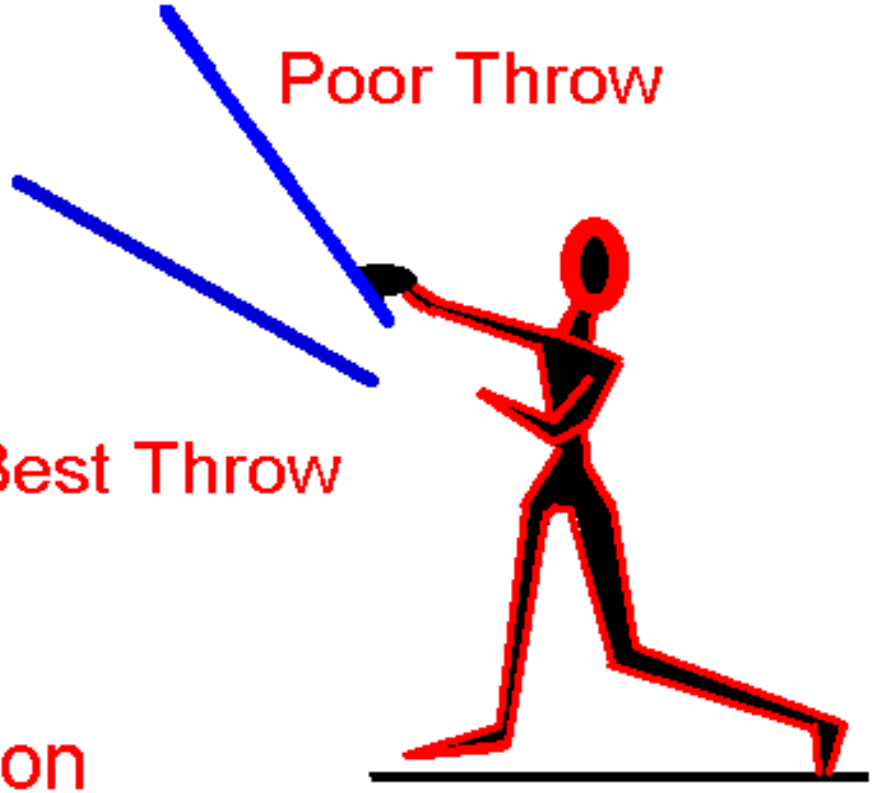
Enter Root Filename [8 Chars]
Filename:WASHCOM3

Enter-Select
VIEWING Module C.B.A. Inc.

WASHINGTON POOR THROW

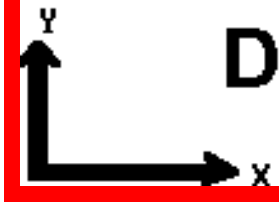


Y
X



Washington

DISCUS THROW KINEMATICS

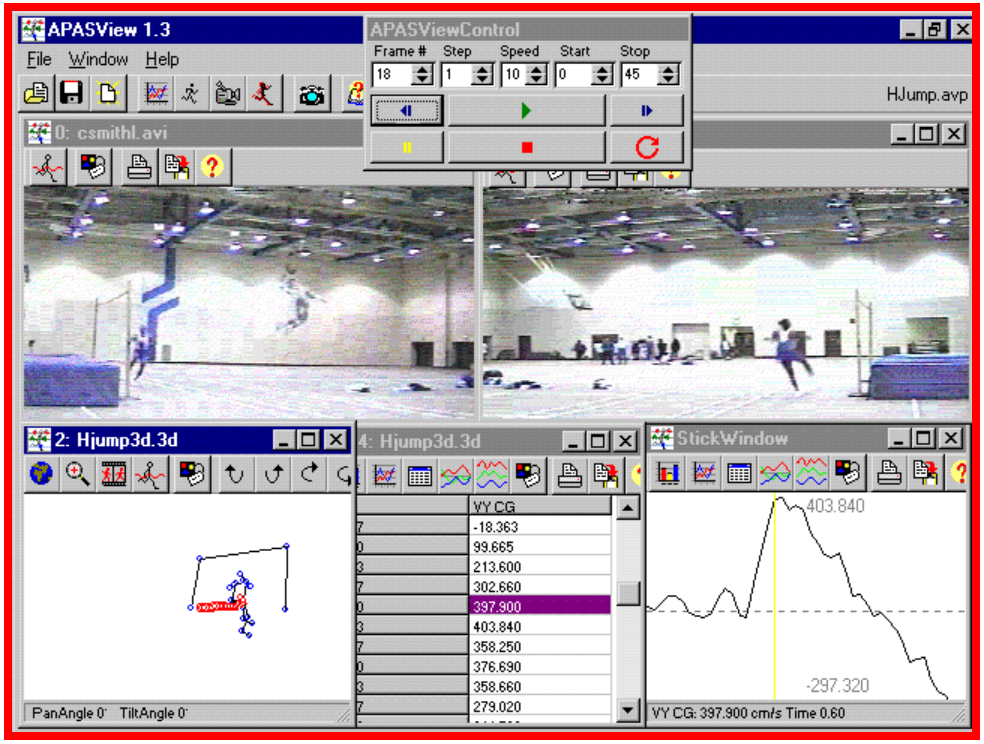


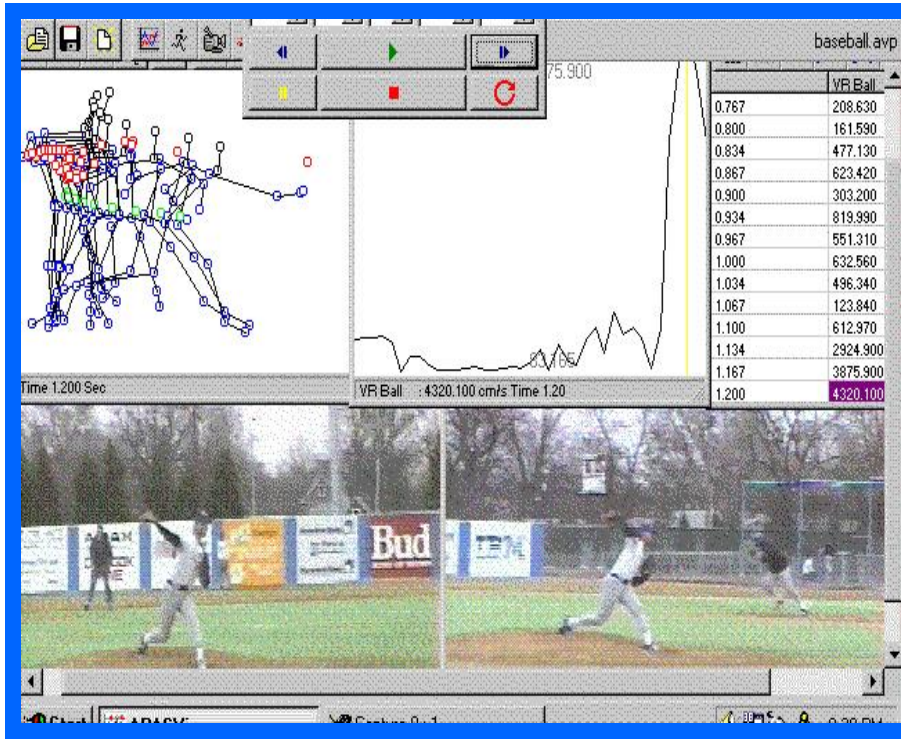
Attempt	Max Angular Horizontal Shoulder Velocity $rad \bullet s^{-1}$	Shoulder Ang Velocity at Release $rad \bullet s^{-1}$
Best Throw	26.1	13.7
Worst Throw	20.1	11.2
% Change	-23%	-18%

Discus Conclusions

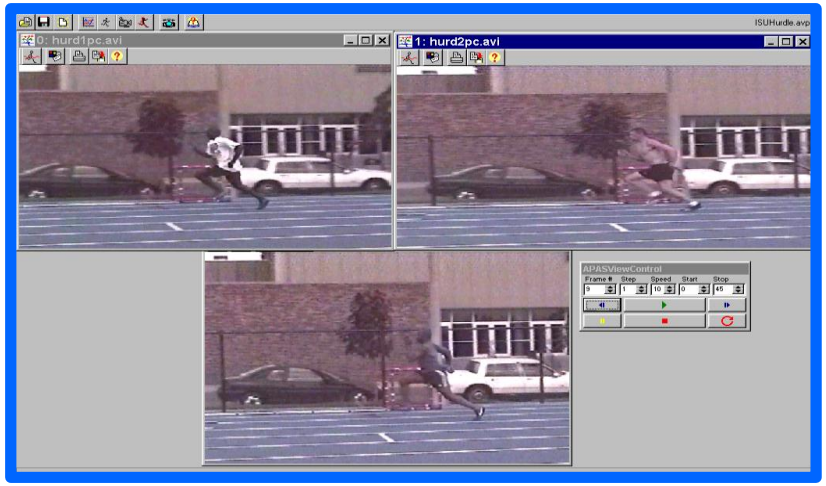
- The poor attempt had a -4% slower resultant disc velocity and a decrease of 43% in horizontal velocity.
- The poor attempt was released at 100% steeper angle.
- Horizontal angular shoulder velocity was 18% slower at release for the poor throw.

Program Integration and Synchronization



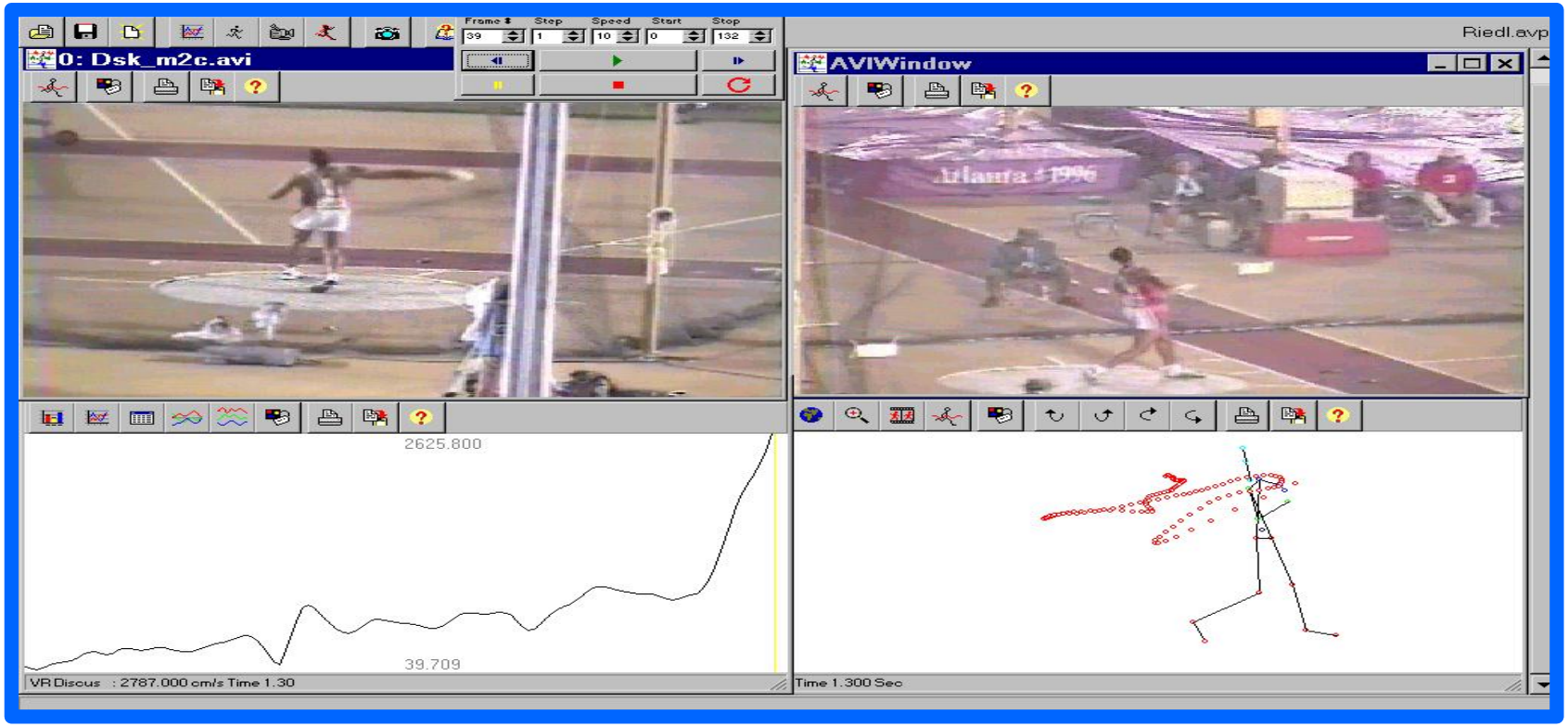


TECHNIQUE COMPARISONS USING VIDEO DISPLAY



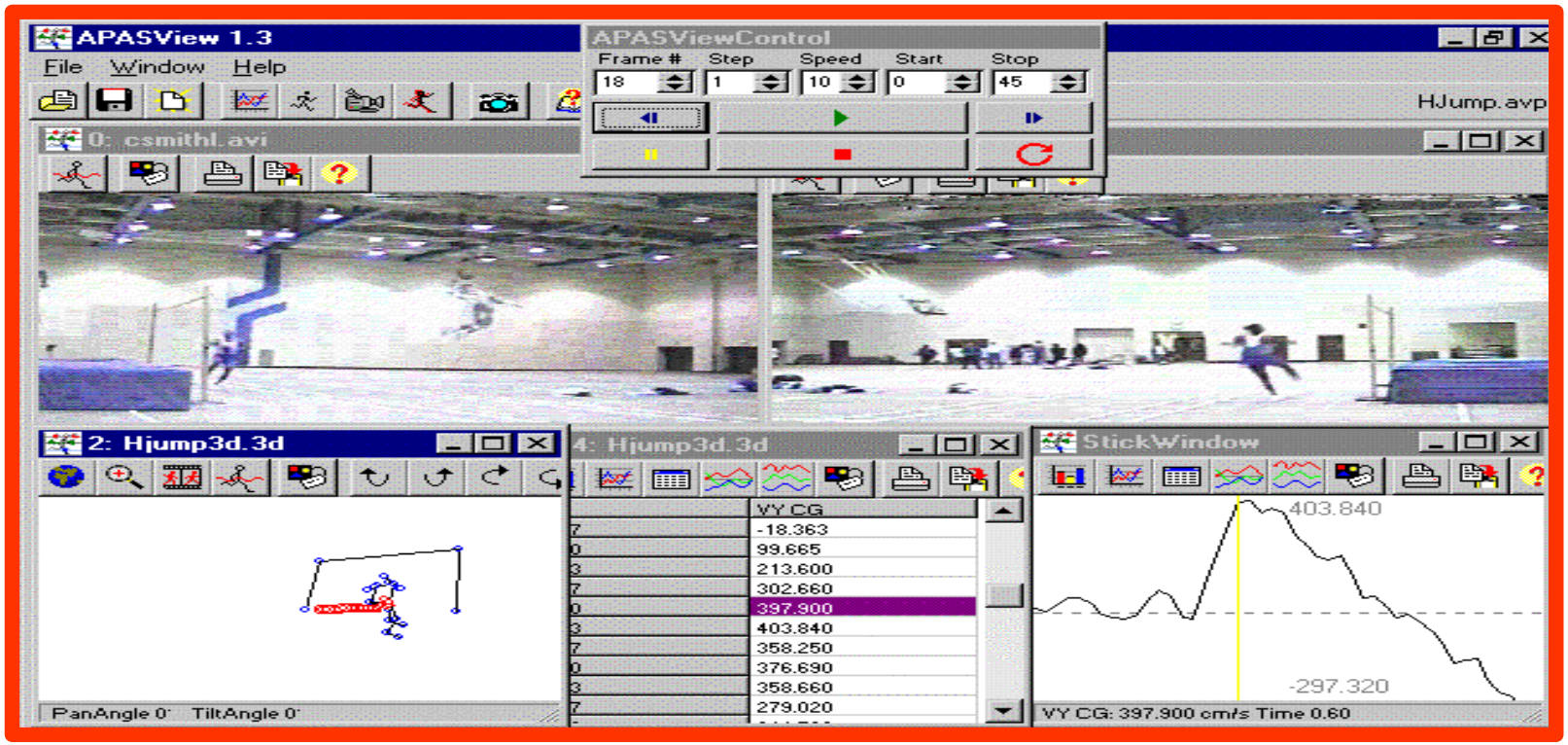
Discus Throwing Analysis Using Video Viewing Option

Video View--The video viewing function permits the biomechanist to observe a sport or functional movement from multiple perspectives, simultaneously. This allows the coach or clinical to perform sport or clinical evaluations at sampling rates that may be 2-10 times faster than visual observations depending on the video cameras transport rate.

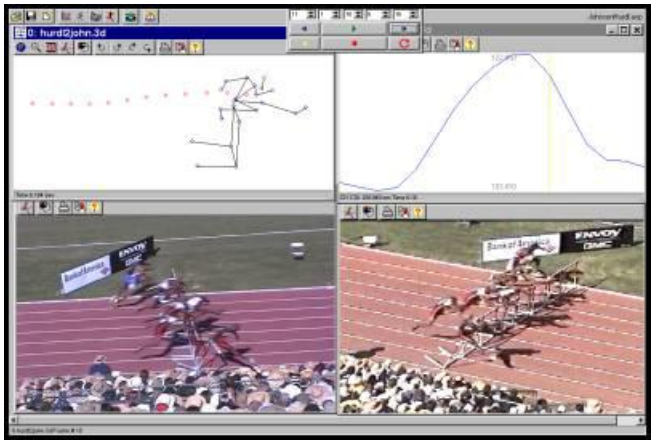


High Jump Analysis Using Integrated Data Option

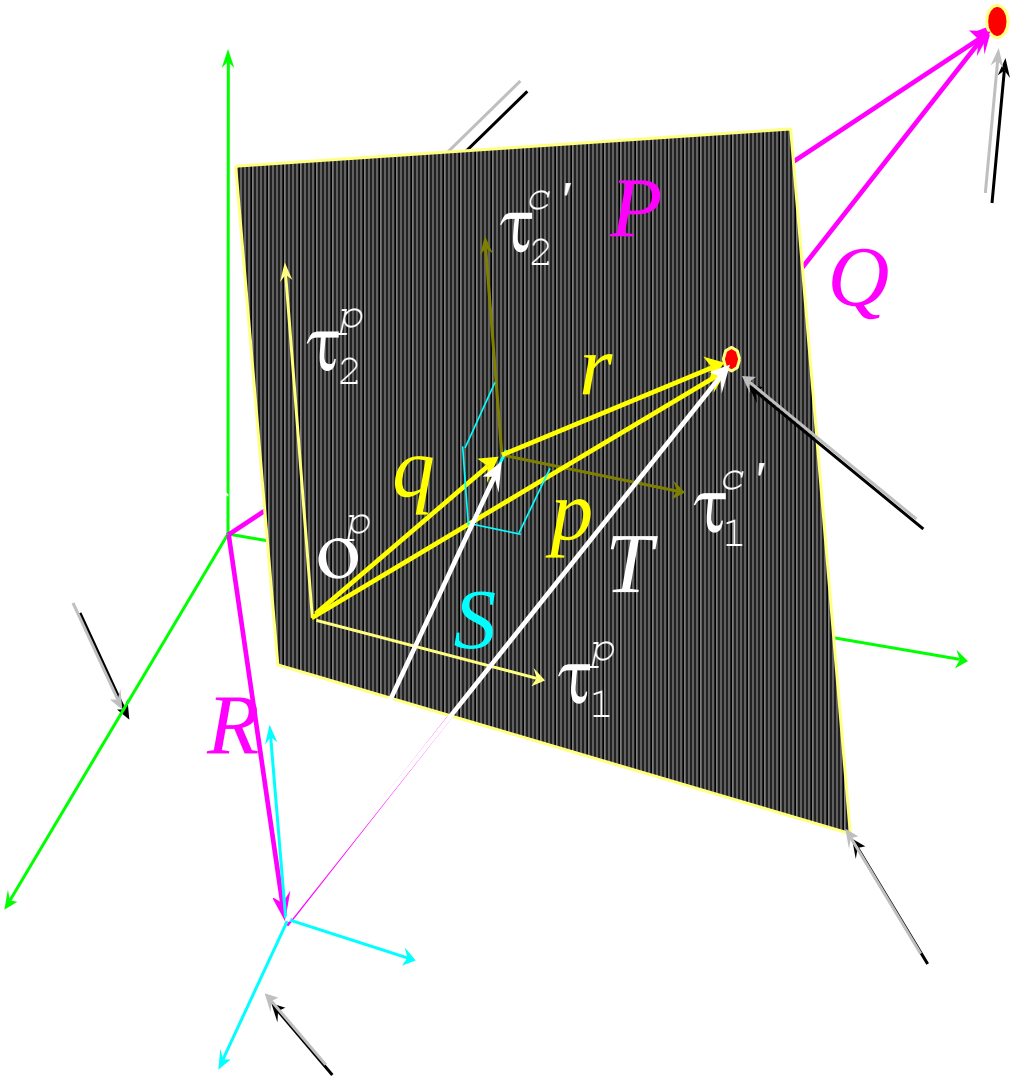
Data View -- The data view is capable of showing many different kinds of numerical data parameters, such as, displacement, velocity, force, EMG and so on. Each channel loaded can be manipulated numerically in order to normalize and modify the data. Each individual data channel can utilize a unique color and a label can be added. The data view can present the data in three different formats, namely, line graphs, bar graphs and numerical table values.



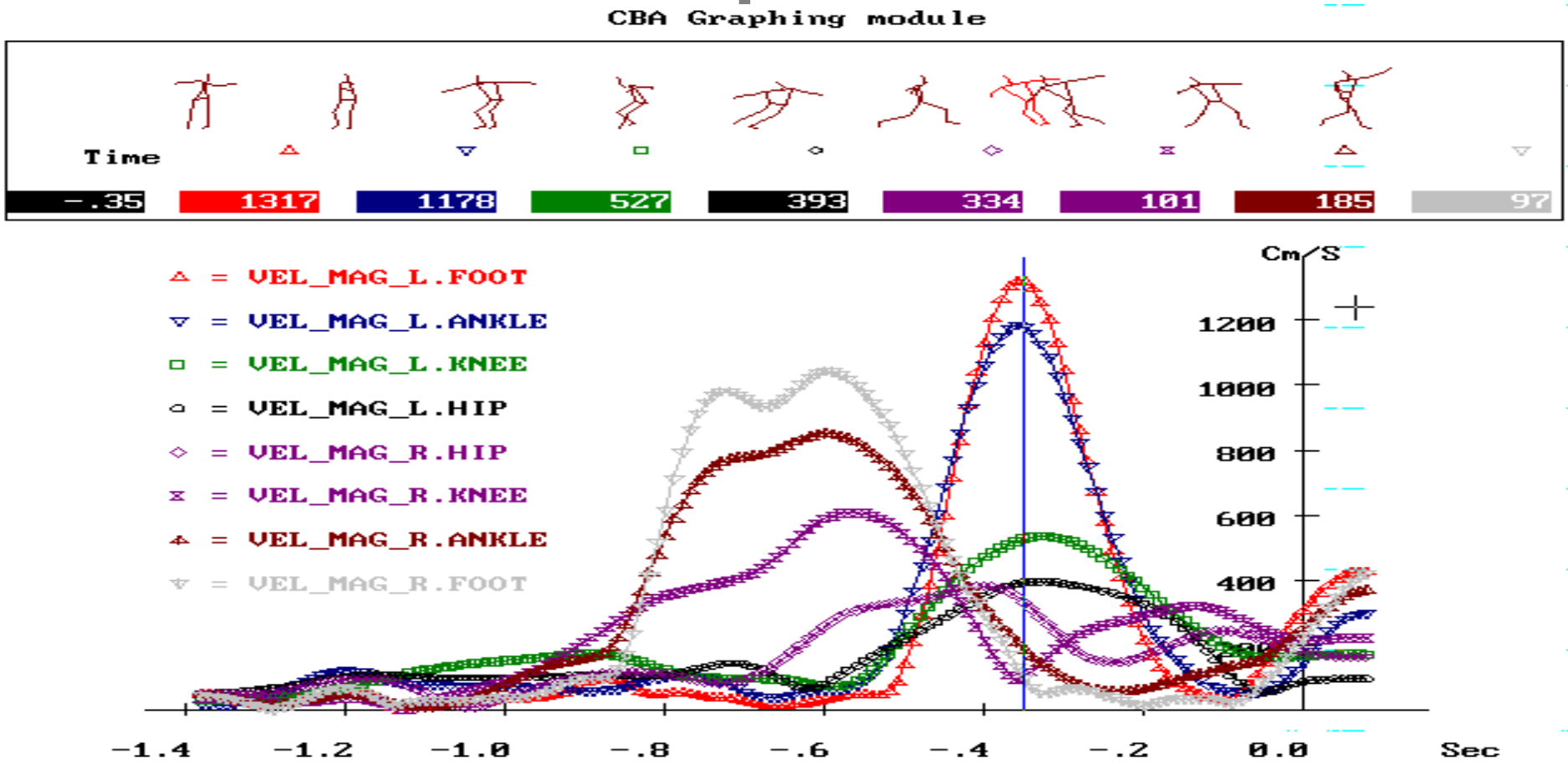
Capturing from TV



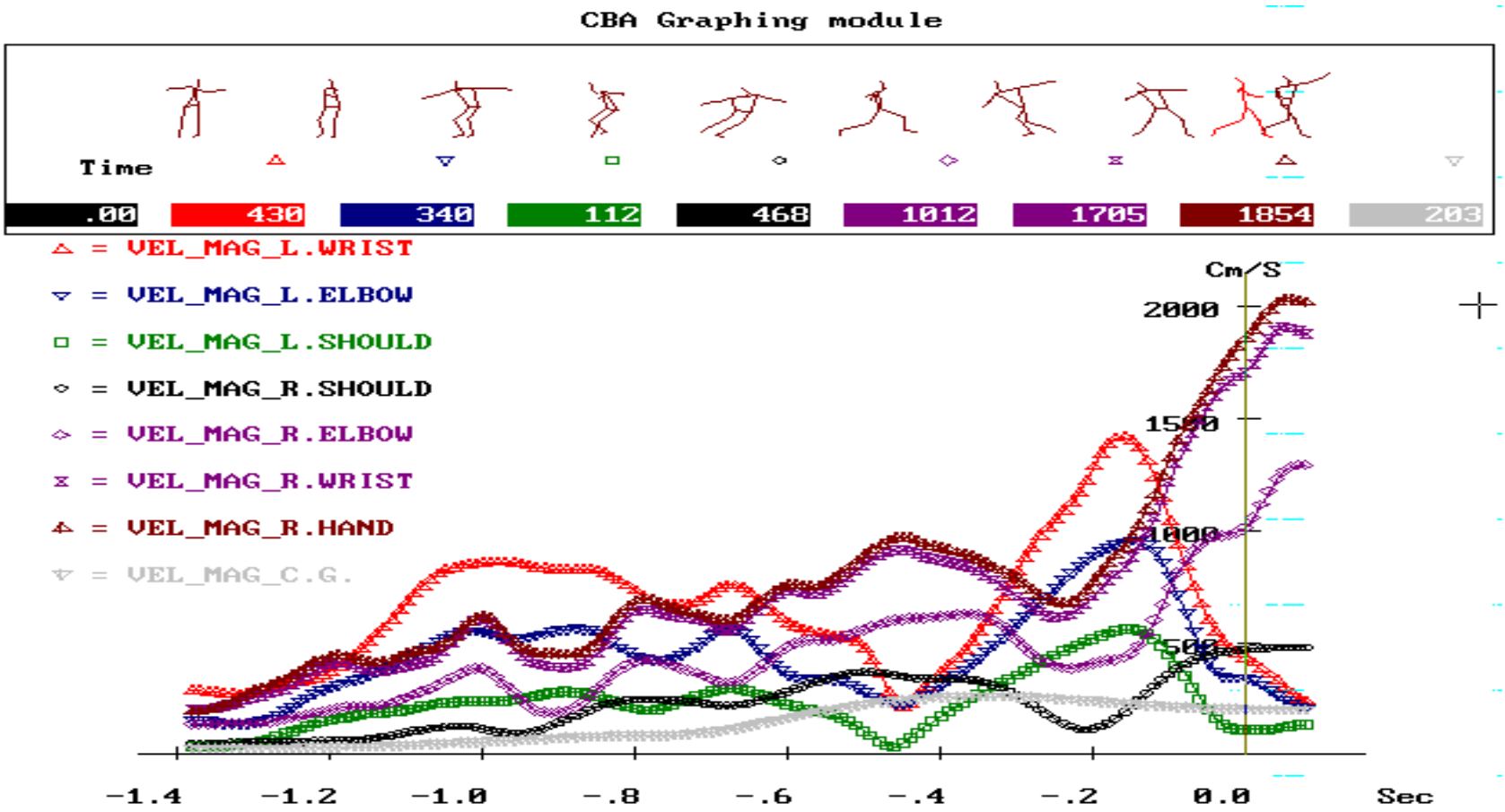
Photogrammetric Physical Parameters

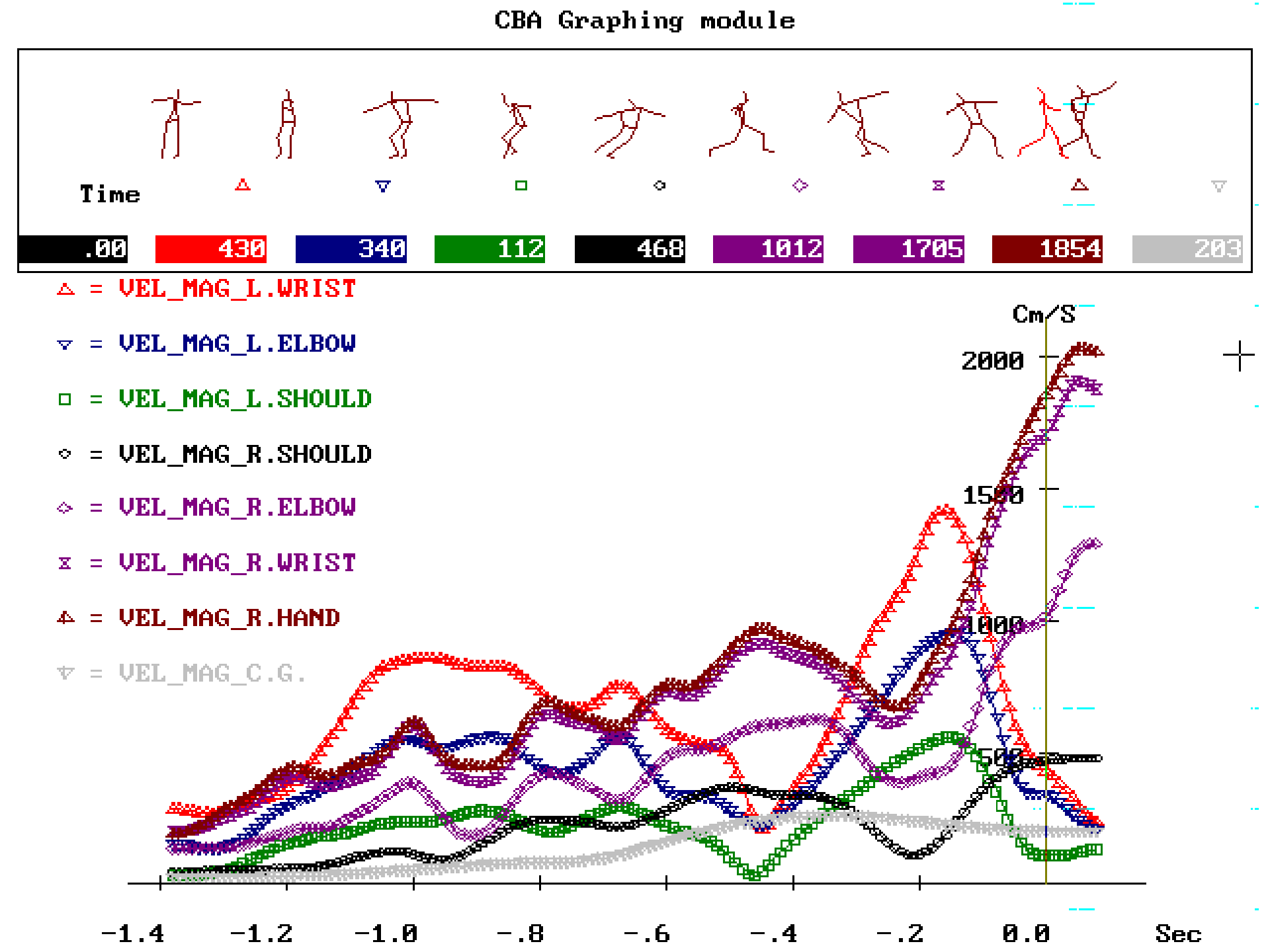


Calculating the Velocities of the lower limb revealed acceleration and deceleration patterns in a unique sequence

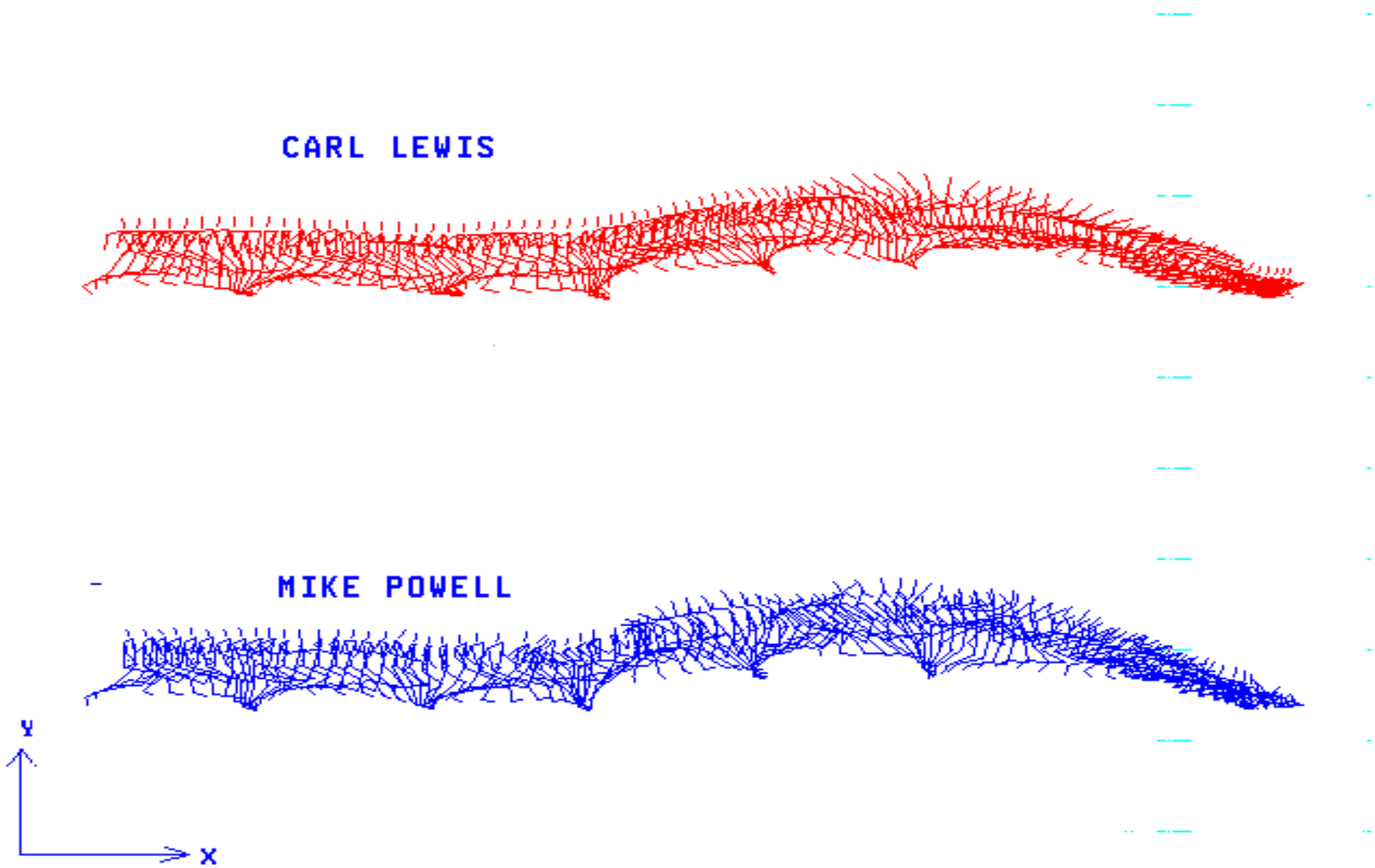


Observing the upper extremities reveals a pattern as well.

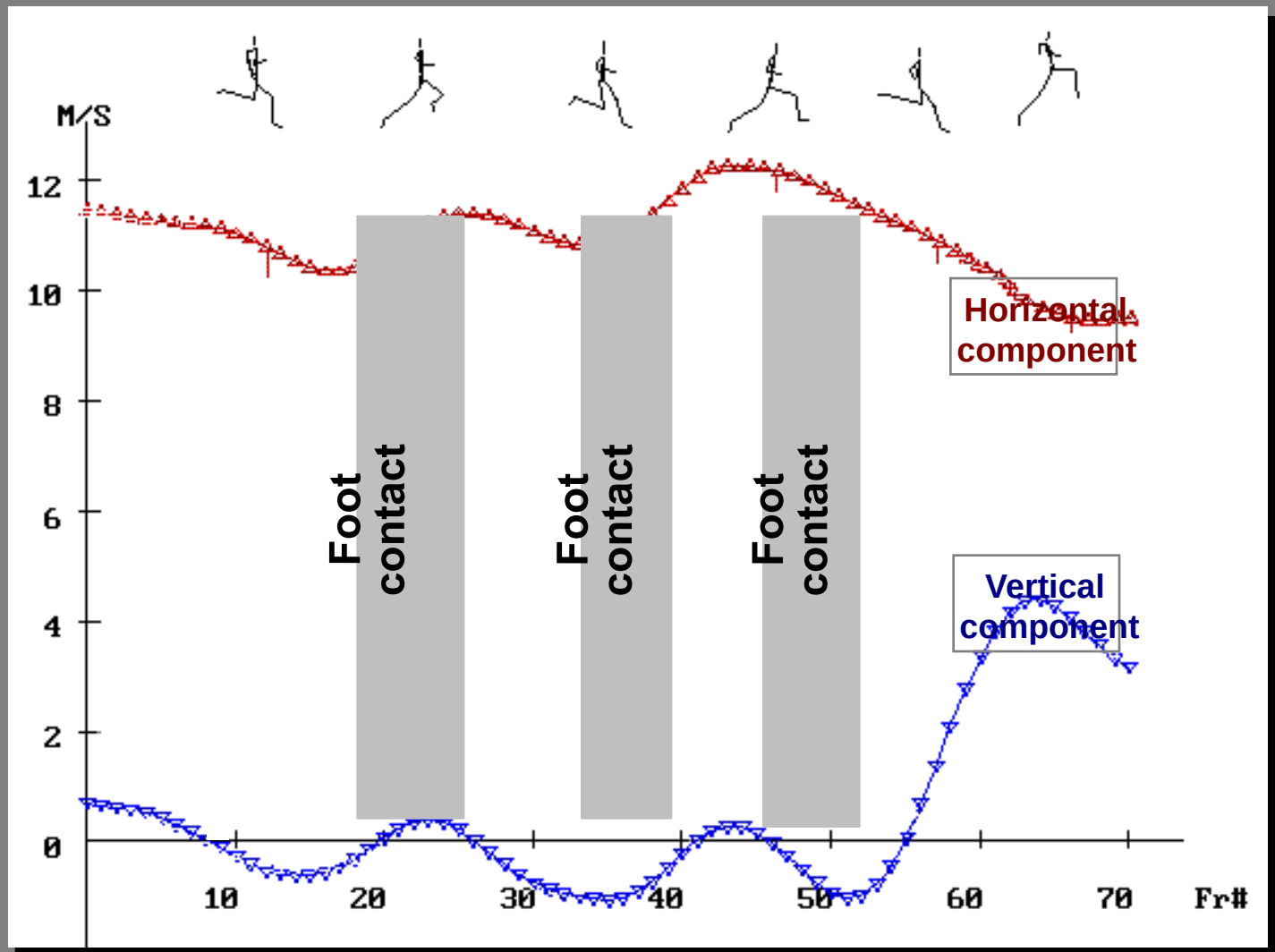



CBA Graphing module
Time
.00
430
340
112
468
1012
1705
1854
203
△ = VEL_MAG_L.WRIST
▽ = VEL_MAG_L.ELBOW
□ = VEL_MAG_L.SHOULD
◇ = VEL_MAG_R.SHOULD
◇ = VEL_MAG_R.ELBOW
⧖ = VEL_MAG_R.WRIST
△ = VEL_MAG_R.HAND
▽ = VEL_MAG_C.G.
Cm/S
2000
1500
1000
500
-1.4
-1.2
-1.0
-.8
-.6
-.4
-.2
0.0
Sec

THE CASE OF THE LONG JUMP:

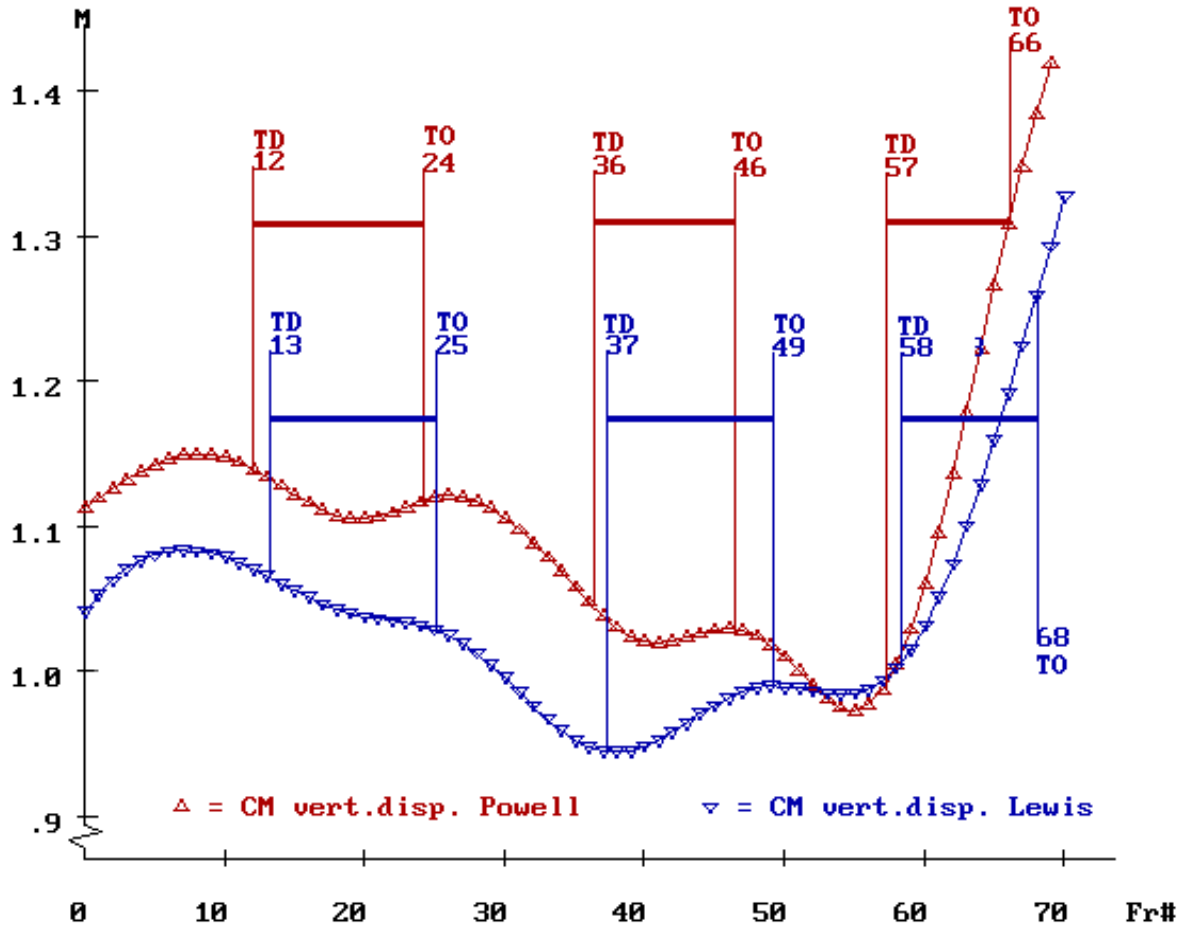


Velocity of the Center of Mass

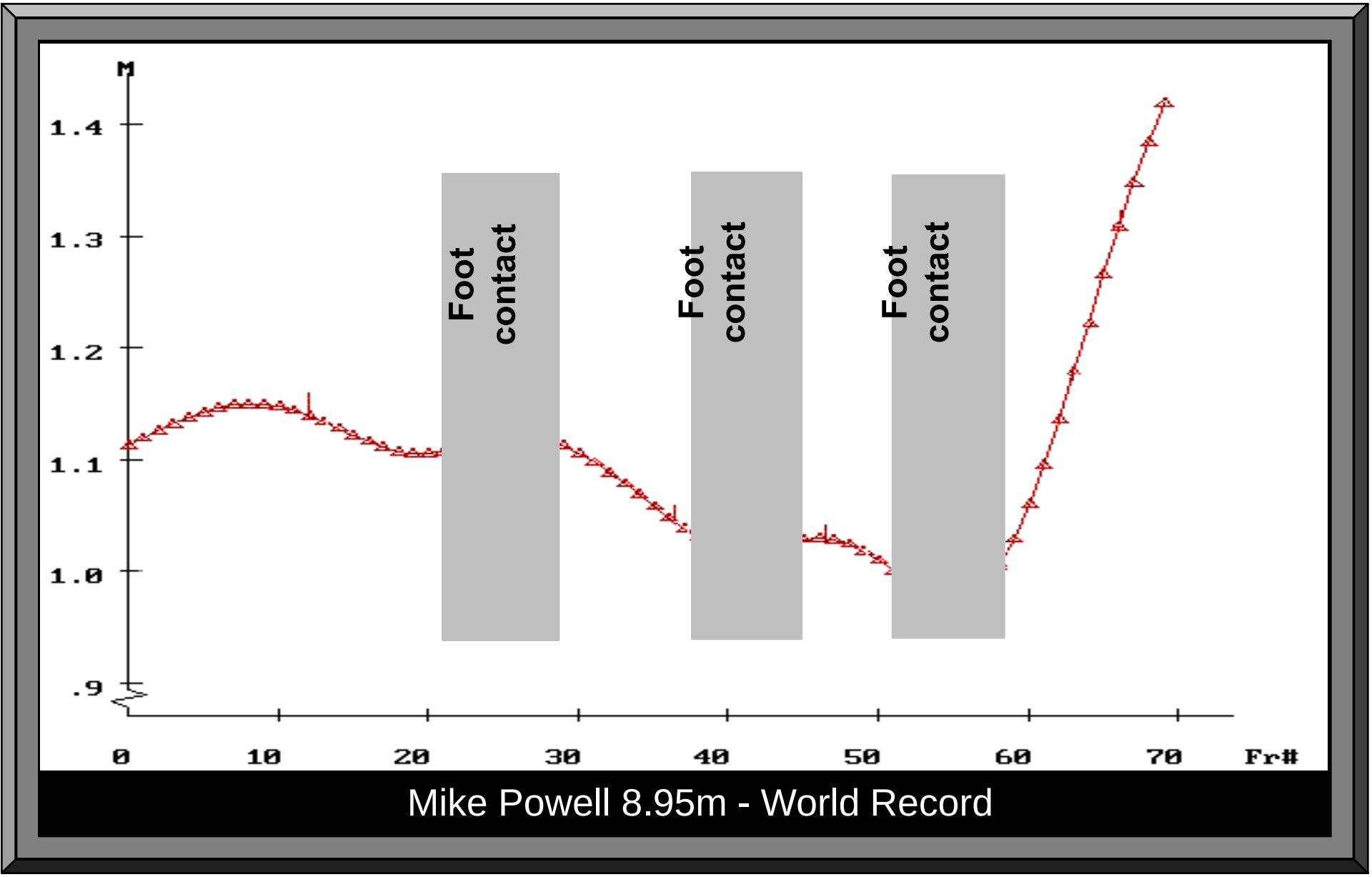


Mike Powell 8.95m - World Record

Change of the Height of CM



Height of the Center of Mass

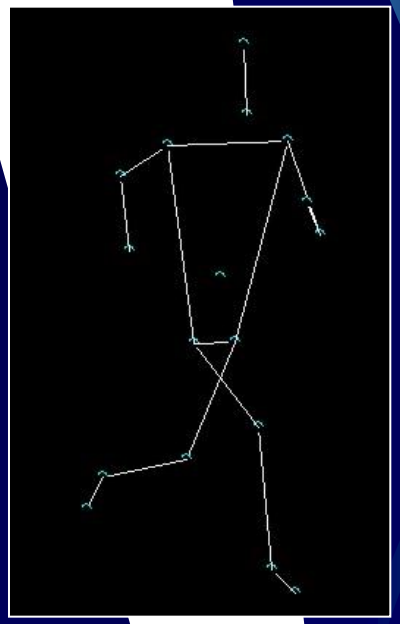


Mike Powell 8.95m - World Record

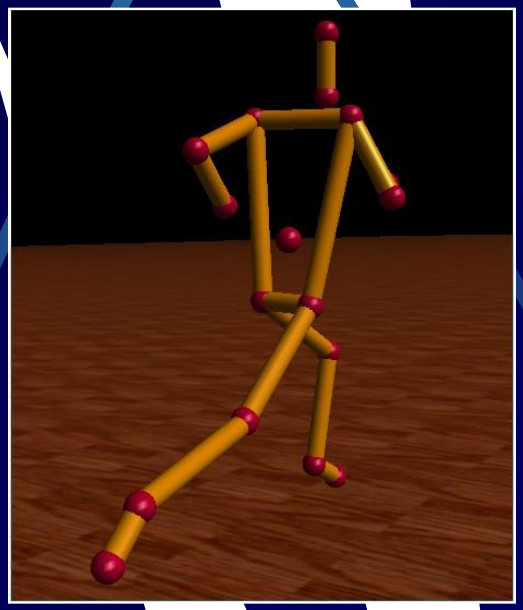
Comparative Kinematic Characteristics

Parameters of the Long Jump	M.Powell	C.Lewis
General Information		
Official Distance [m]	8.95	8.91
Effective Distance [m]	8.98	8.91
Favorable Wind Velocity [m/s]	0.3	2.9
The Approach		
Average Speed: 11-6m to the Board [m/s]	10.79	11.23
Average Speed: 6-1m to the Board [m/s]	10.94	11.26
The Length of the Third-Last Stride [m]	2.4	2.23
The Length of the Second-Last Stride [m]	2.47	2.7
The Length of the Last Stride [m]	2.28	1.88
The Take-Off		
CM Horizontal Velocity [m/s]	9.27	9.11
CM Vertical Velocity [m/s]	4.21	3.37
Angle of Projection [deg]	24.1	20.3
Angle of body Lean at Touch-Down [deg]	71.8	77
Angle of body Lean at Take-Off [deg]	73.9	67.5

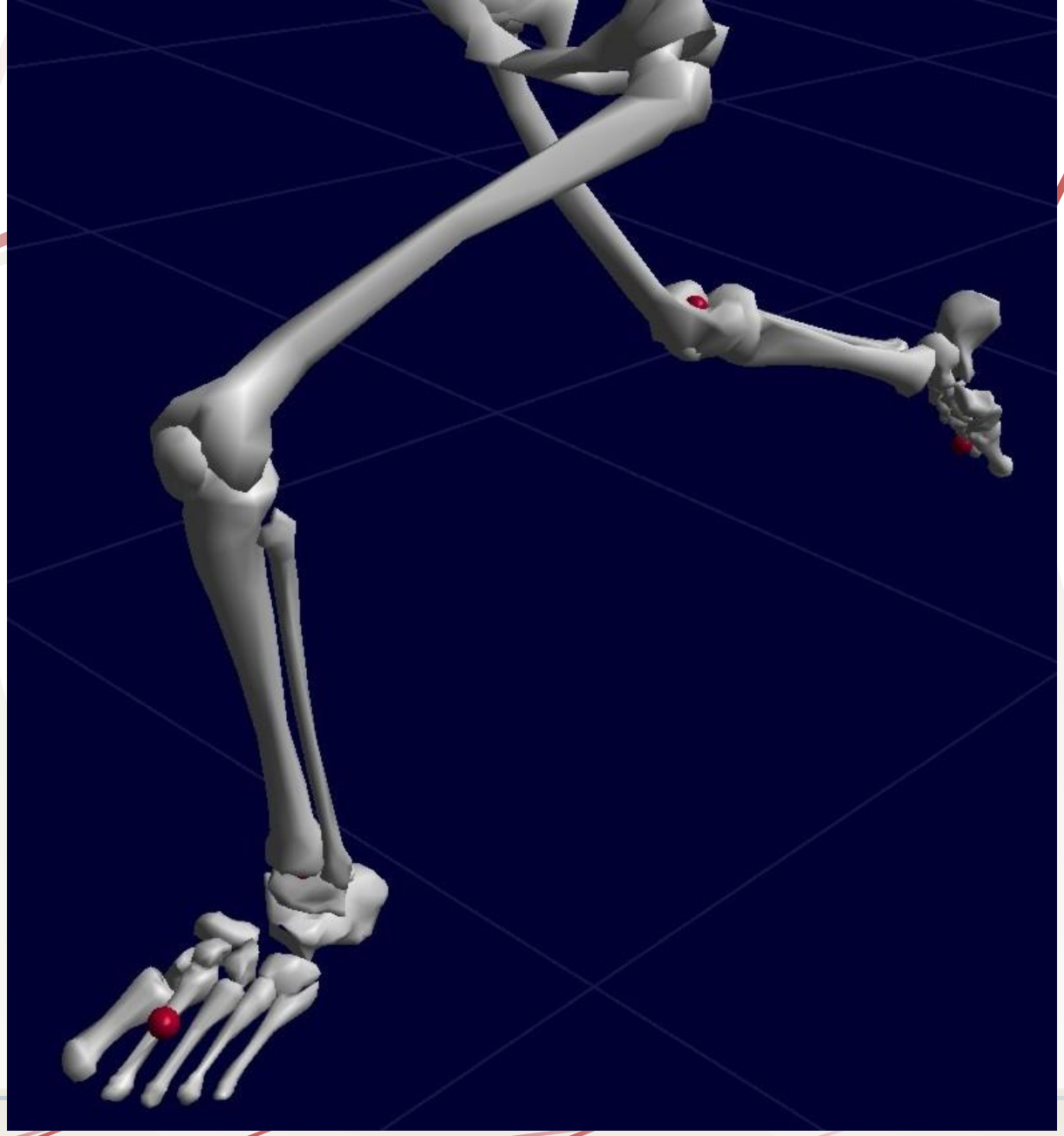
Real-time rendering

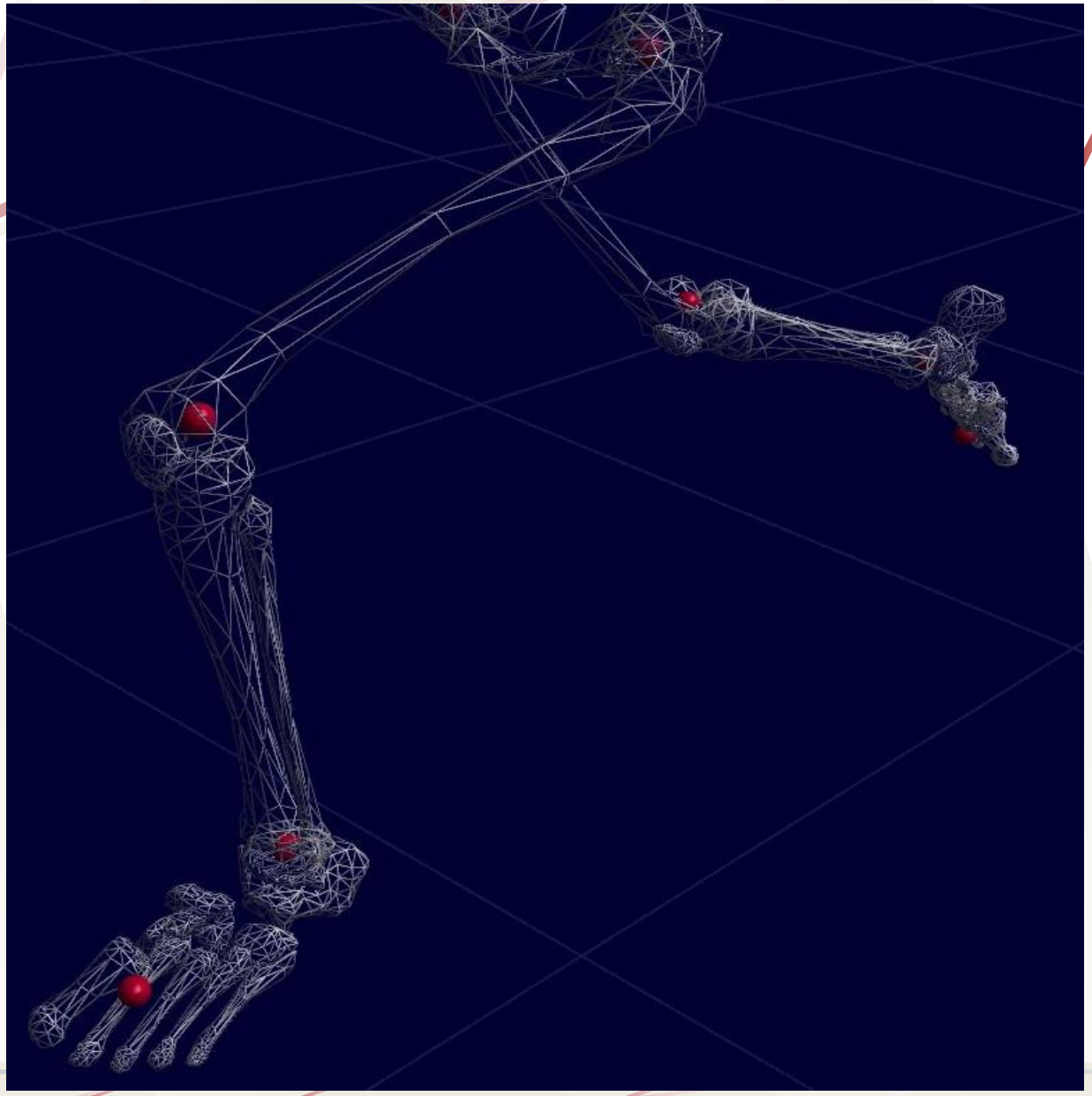


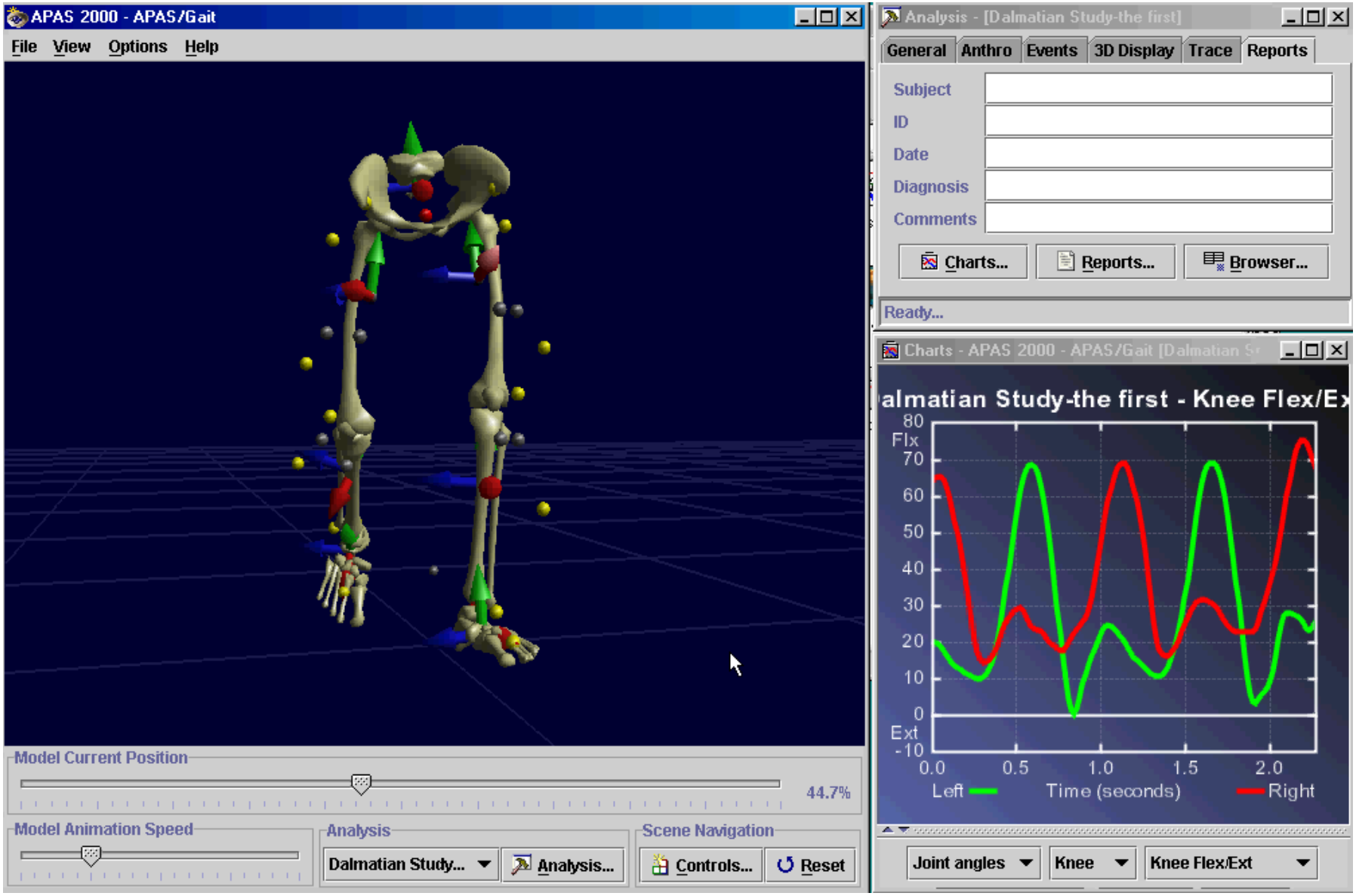
Traditional stick figure



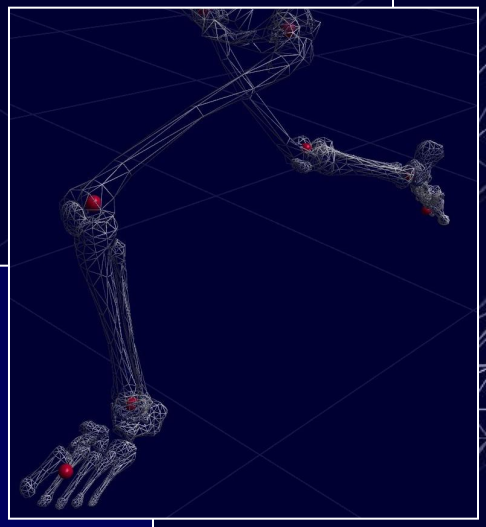
Real-time rendering






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
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

What is Rendering anyway?



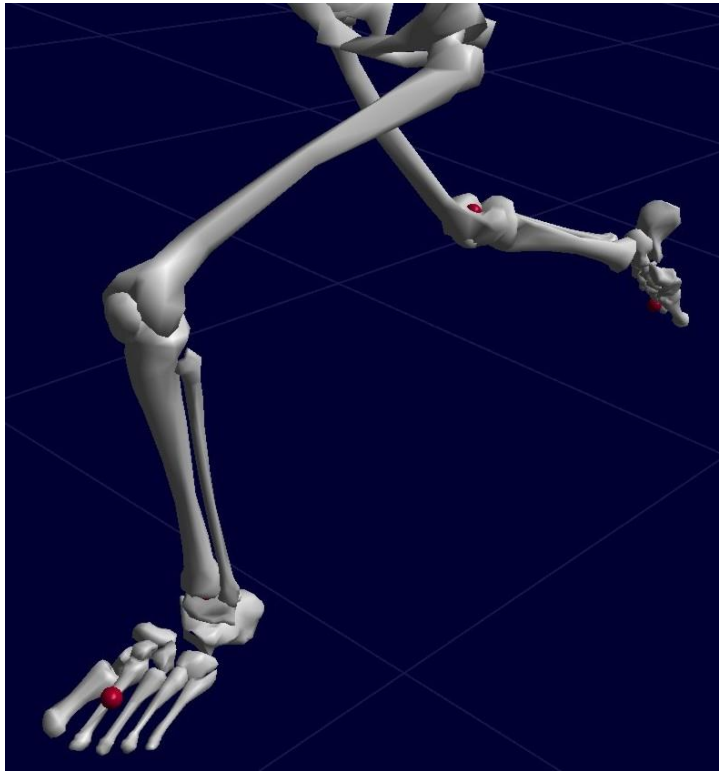
Definition of:

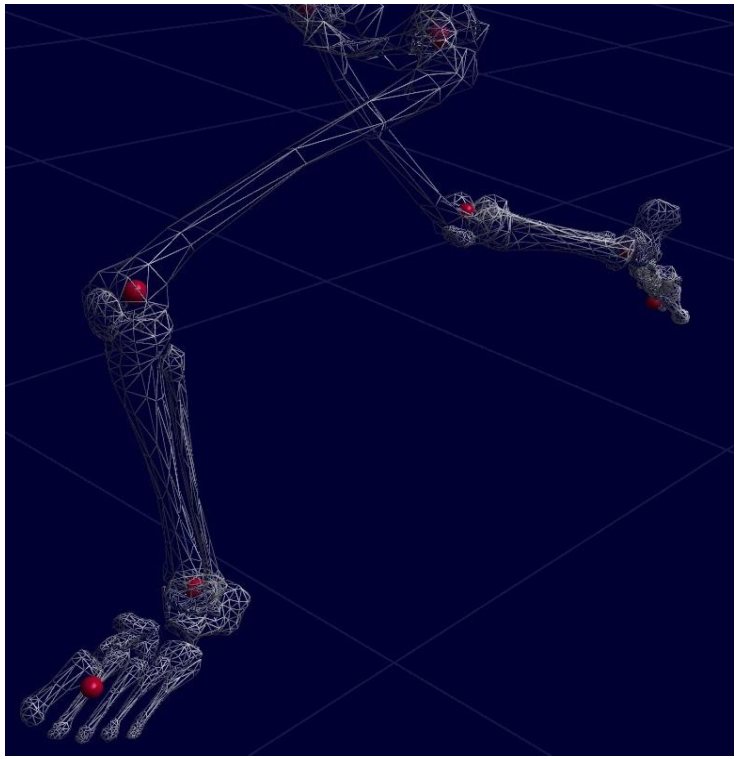
- Graphic objects
- Lighting
- Environmental effects
- Behavior
- Physical characteristics

Calculate views:

- Computer screens
- Immersive workbench
- Head-tracked glasses

Renderer Examples





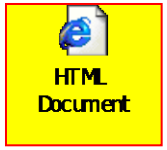
PROVIDE SIMULTANEOUS INTEGRATION OF:

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

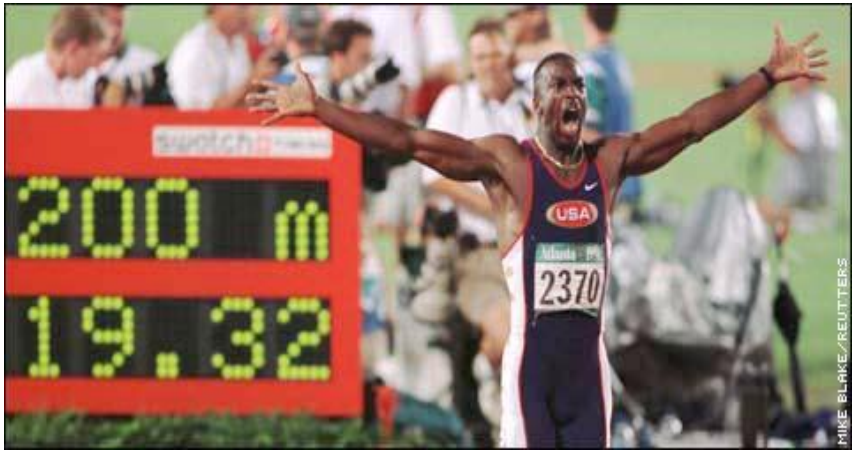
•**Applications**

- COACHING
- SPORT PERFORMANCE ANALYSIS
- OPTIMIZATION OF PERFORMANCE

Biomechanical Analysis from TV Broadcasts



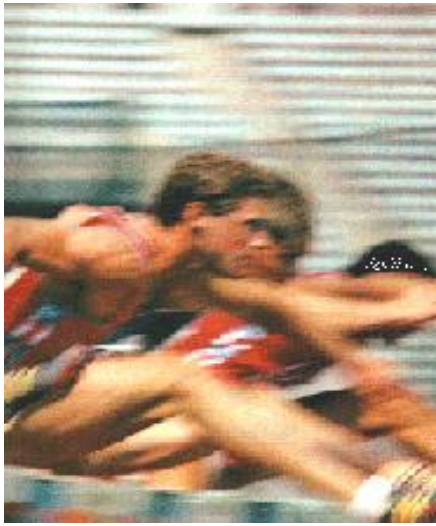
Hammer1.avi


200 m
19.32
USA
2370
MIKE BLAKE/REUTTERS


3478
3298
5
3
Ross Kinnaird/Allsport

RUN1.AVI

Hurdle1.avi



PV1.AVI

History was made at the Atlanta Games by utilizing the Internet to provide Biomechanical data immediately for use at remote sites

The Internet has opened a new frontier for research and international cooperation on multifaceted studies.

Under the auspices of the International Track and Field Coaches Association, the track and field events which were performed at the Atlanta Olympics in 1996, were selected to illustrate these procedures because these activities uniquely captivate an enthusiastic world-wide audience

History was made at the Atlanta Games by utilizing the Internet to provide Biomechanical data immediately for use at remote sites

- **This was a new and innovative procedure that allows immediate sending of video information all around the world for immediate analysis at different locations**

The Future – The Virtual Coach

- 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. Coach_virtual provides a search capability for videos, 3D/2D Files capability for users to communicate in forums of like interest.
  - Each Coach is a download/upload source
  - Each User Computer, when it is on, it becomes a shared directory
  - For more information: http://www.arielnet.com

The Future

- A user records and stores Video file in a specific folder on his or her hard disk
- A central directory maintained by Coach.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 Coach.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
- Coach.com monitor and publish the catalogue of activities and sports world wide

THANK YOU