

Sports Analysis in the New Millennium



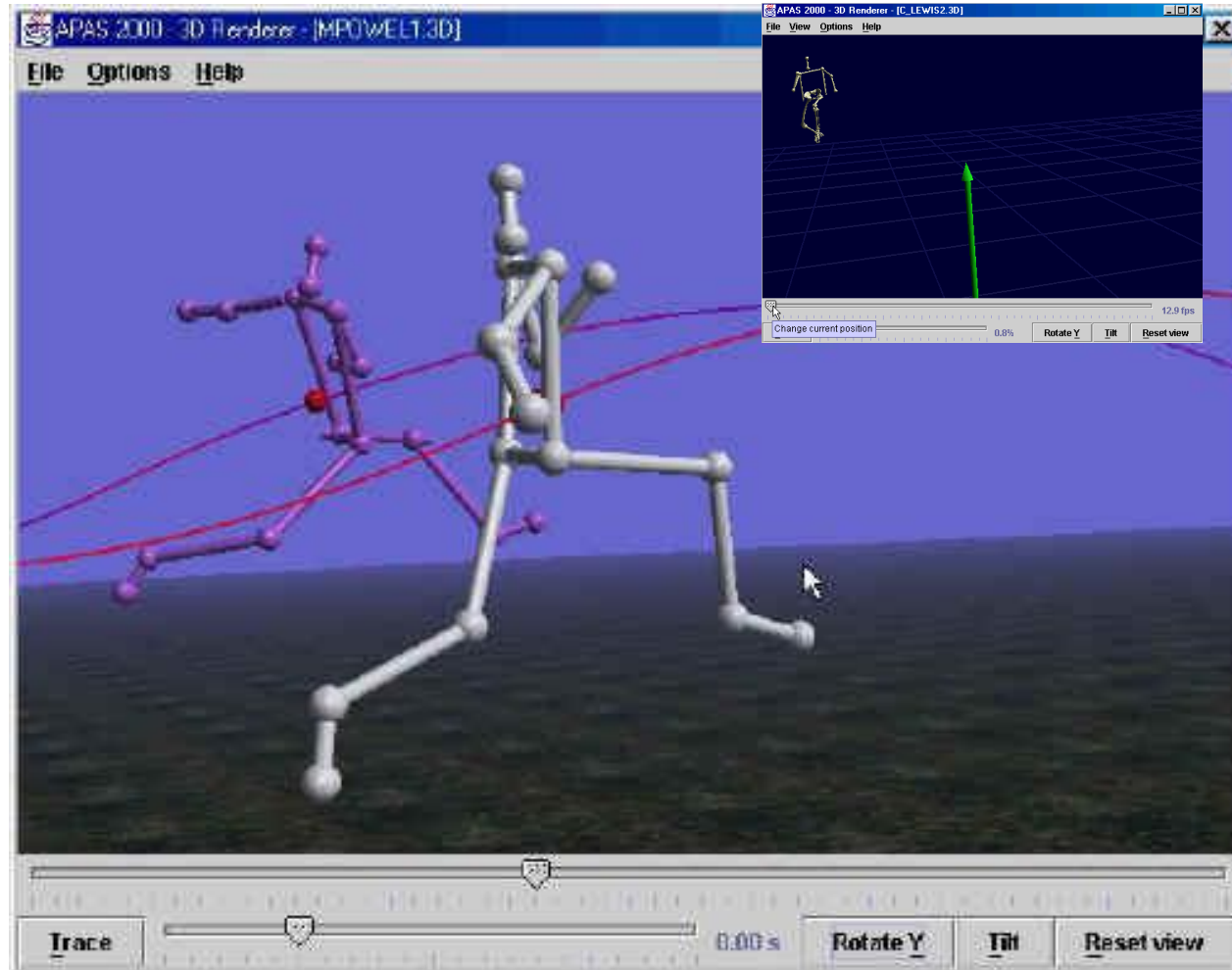
Gideon Ariel, Ph.D.

NCF/BOA High Performance Coaching Workshop

Cardiff, Wales

April 18, 2000

MOVEMENT ANALYSIS CAN BE APPLIED TO:



Athletics

Industry

Medicine

Space

Ariel Performance Analysis System

Video Capturing

General Biomechanics
Functional Capacity
Gait Analysis
Jobsite Analysis

Functional Capacity

Sports Analysis
Post Injury Evaluation
Job Qualification Testing

Kinematic Studies

Lifting
Standing
Sitting
Ladder Climbing

Squatting
Backload
Stairclimbing
Hand Evaluation

APAS

Pre & Post Surgery
Hip Replacements
Knee Replacements
Amputee Gait
Walking Aids
Stroke Patients

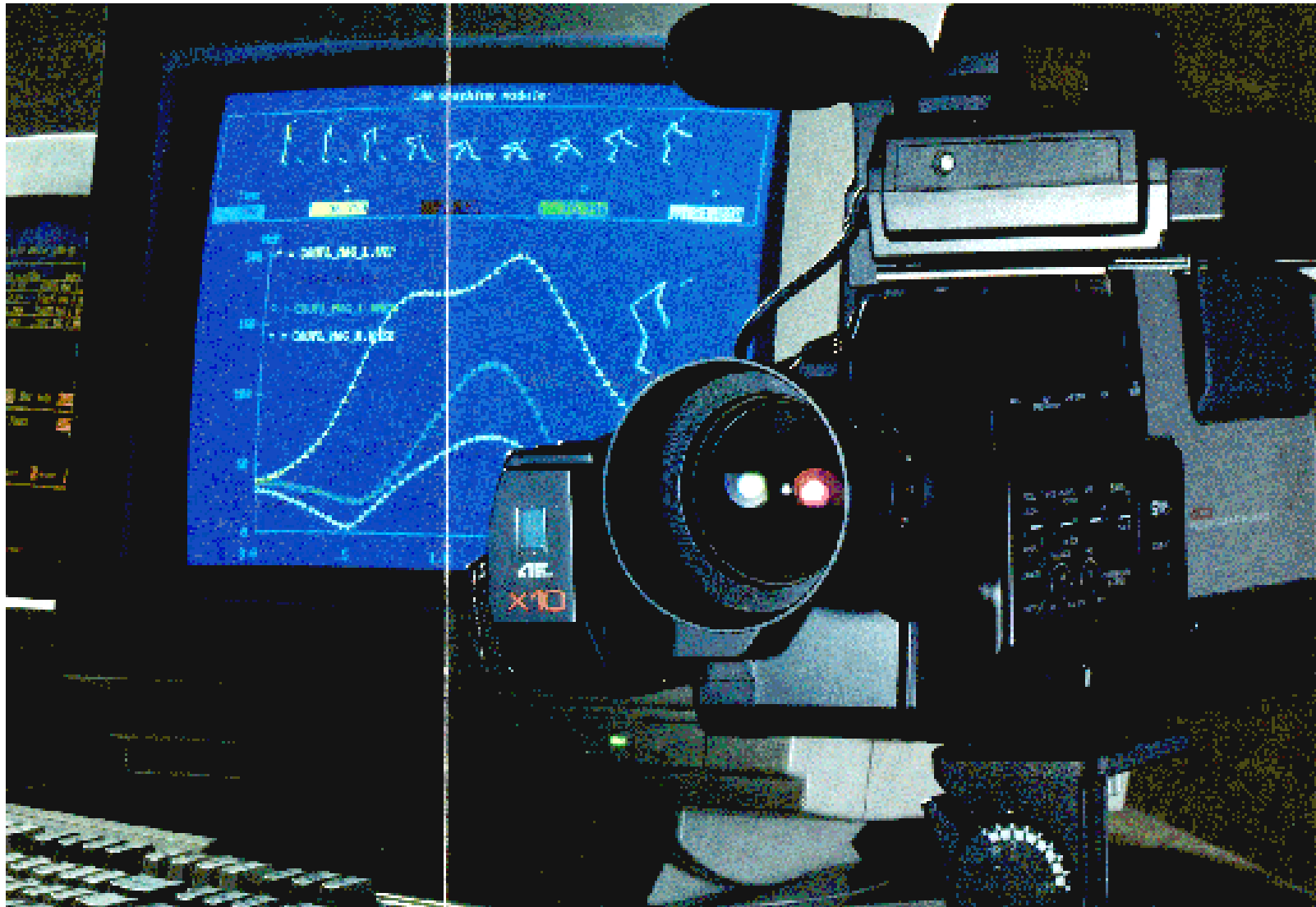
Analog A/D Option

Gait Analysis
Balance Analysis
Impact Studies
Prosthetic Design
Neurological Studies

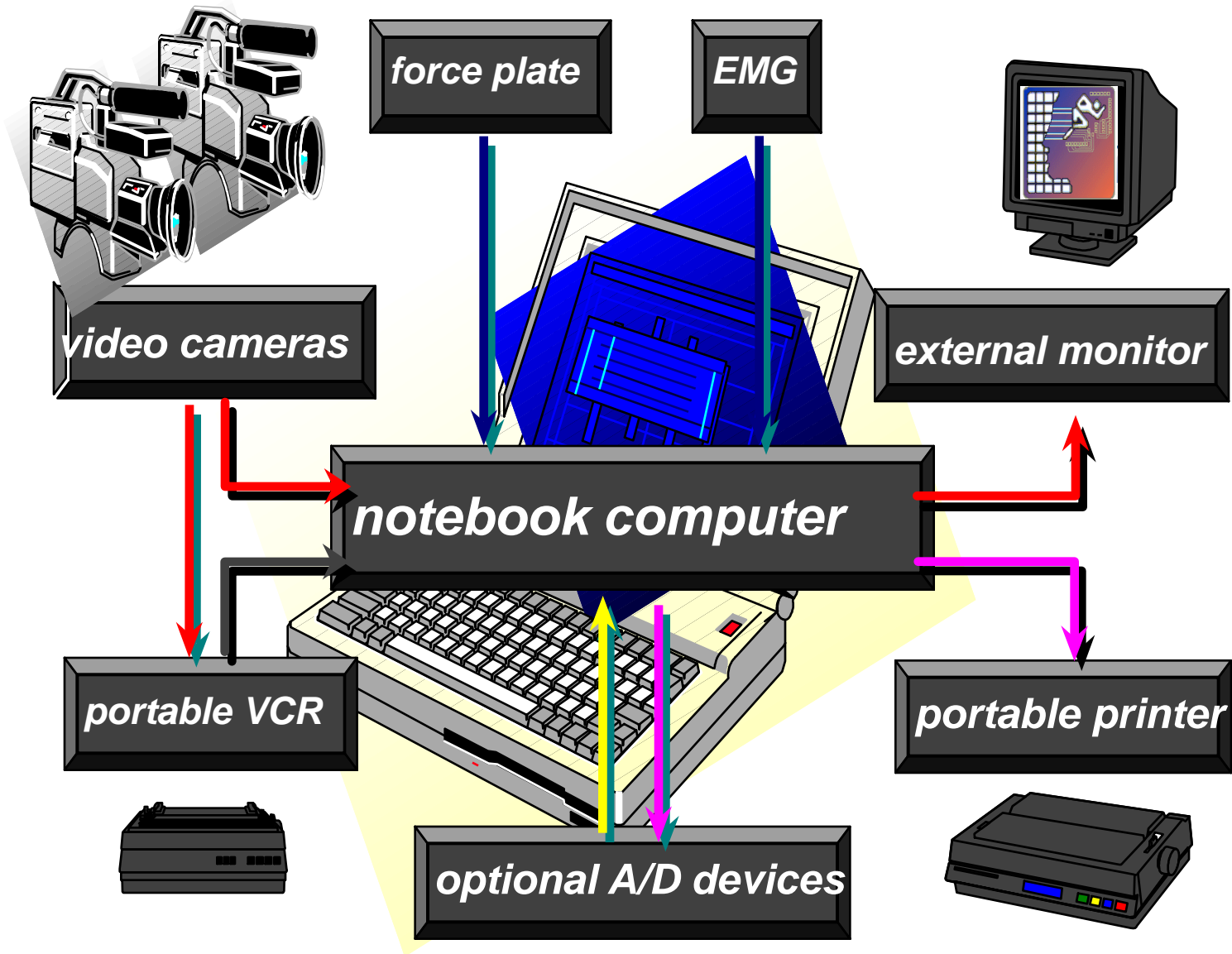
Spine
c.p.
m.d.
m.s.

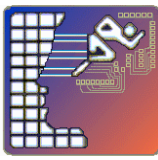
Carpal Tunnel Syndrome

ALL APPLICATIONS UTILIZED SIMILAR QUANTIFICATION TECHNIQUES



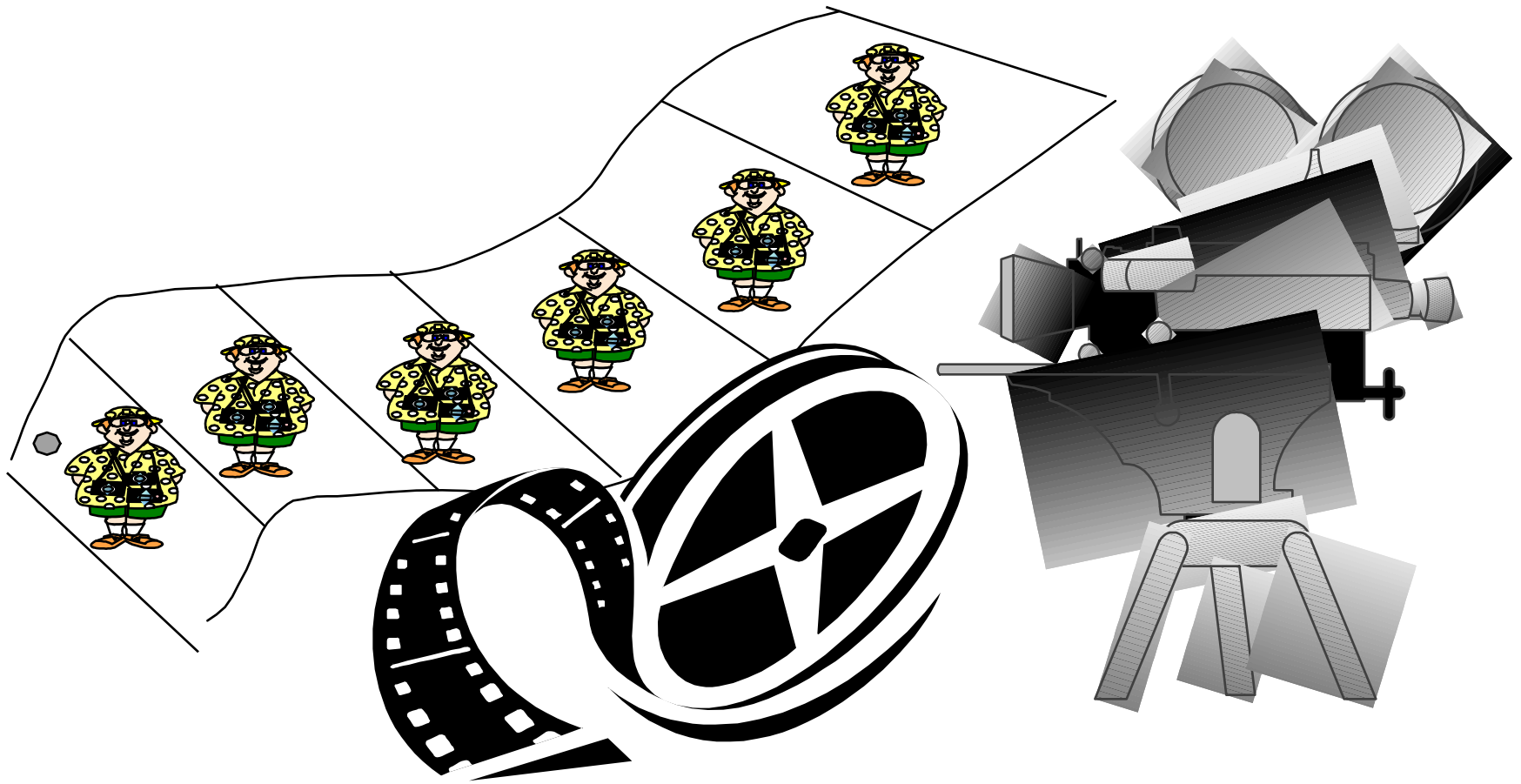
Basic Components of Motion Analysis System

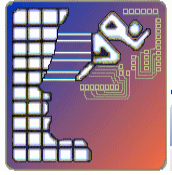




The Early 70's

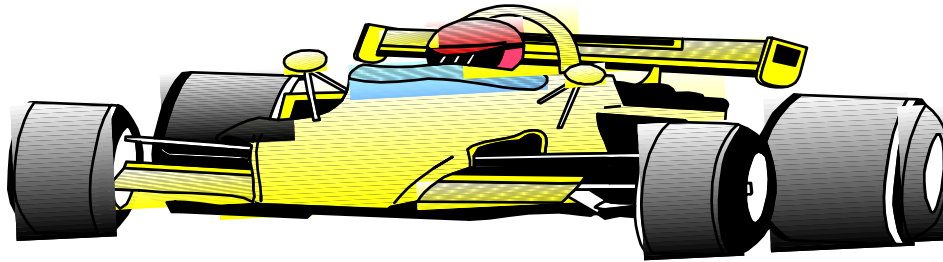
use of high speed cinematography





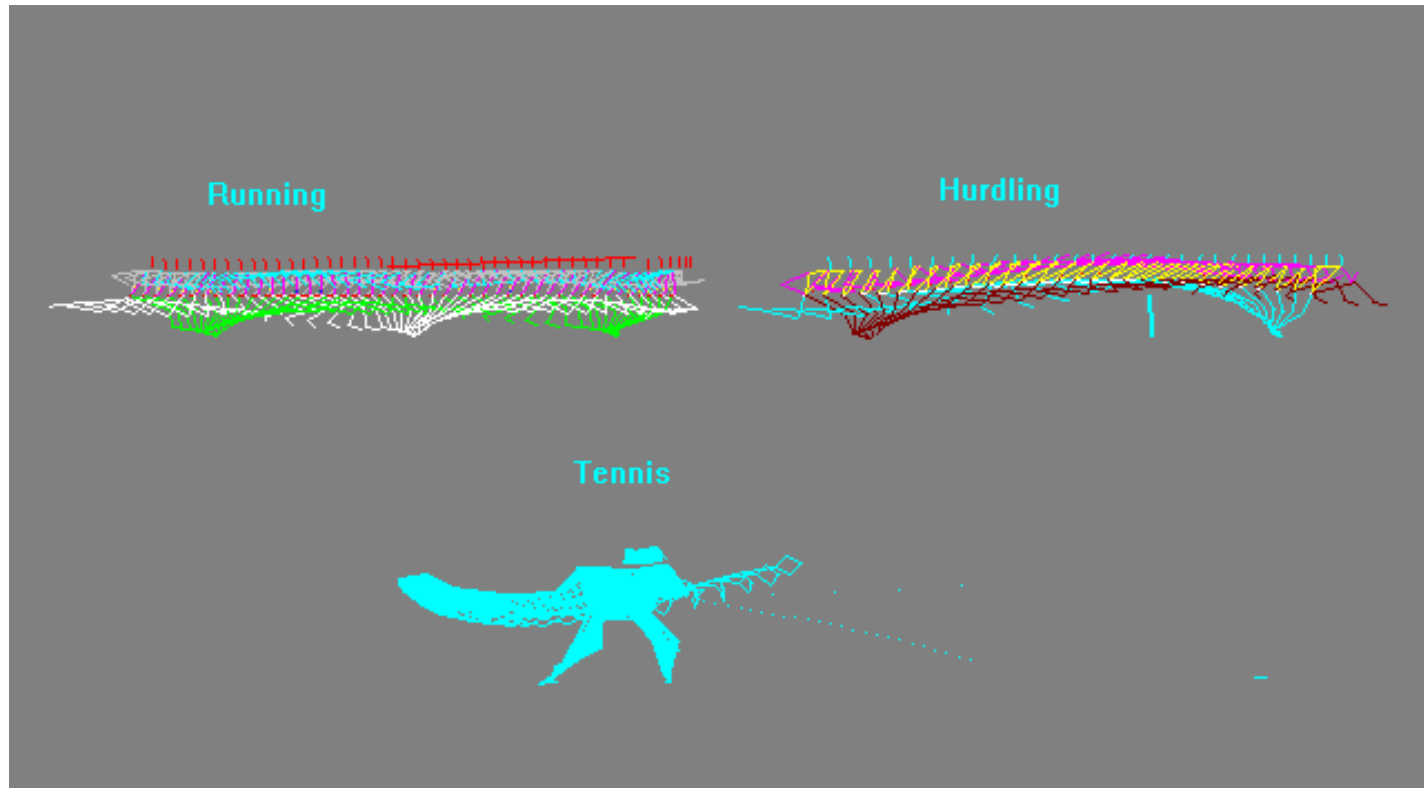
NEW TECHNOLOGIES

For Your Professional Toolbox



- ① Computerized Video Analysis [Kinematics]
- ① Force Plate [Kinetic Ground Reaction] 3D
- ① Dynamic EMG
- ① Internet Interface

Athletic performances can be divided into a wide spectrum of activities.



The Spectrum of Athletic Performances

- Explosive Events

- [Throwing](#)
- Sprinting
- [Jumping](#)



- Endurance Events

- Long Distance Run
- Swimming
- Cycling



- Accuracy Events

- [Golf](#)
- Archery



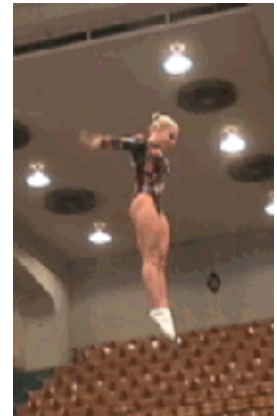
- [Team Sports](#)

- Soccer
- Basketball
- Hockey



- Esthetic Events

- Figure Skating
- [Gymnastics](#)
- Diving



- Multi Events

- Decathlon
- Pentathlon

Analysis of Performance Require:

Video Recording

Digitizing the Data

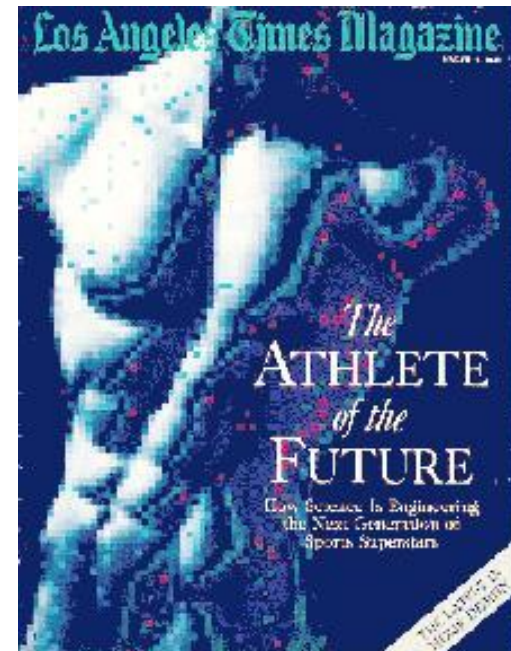
Manual

Automatic

Transformation of the Data

2D - Two Dimensional

3D - Three Dimensional

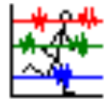


High Speed Camera at 240 Hz

GR-DVL9500U

LCD Monitor VHS Camcorder





Apasview.exe

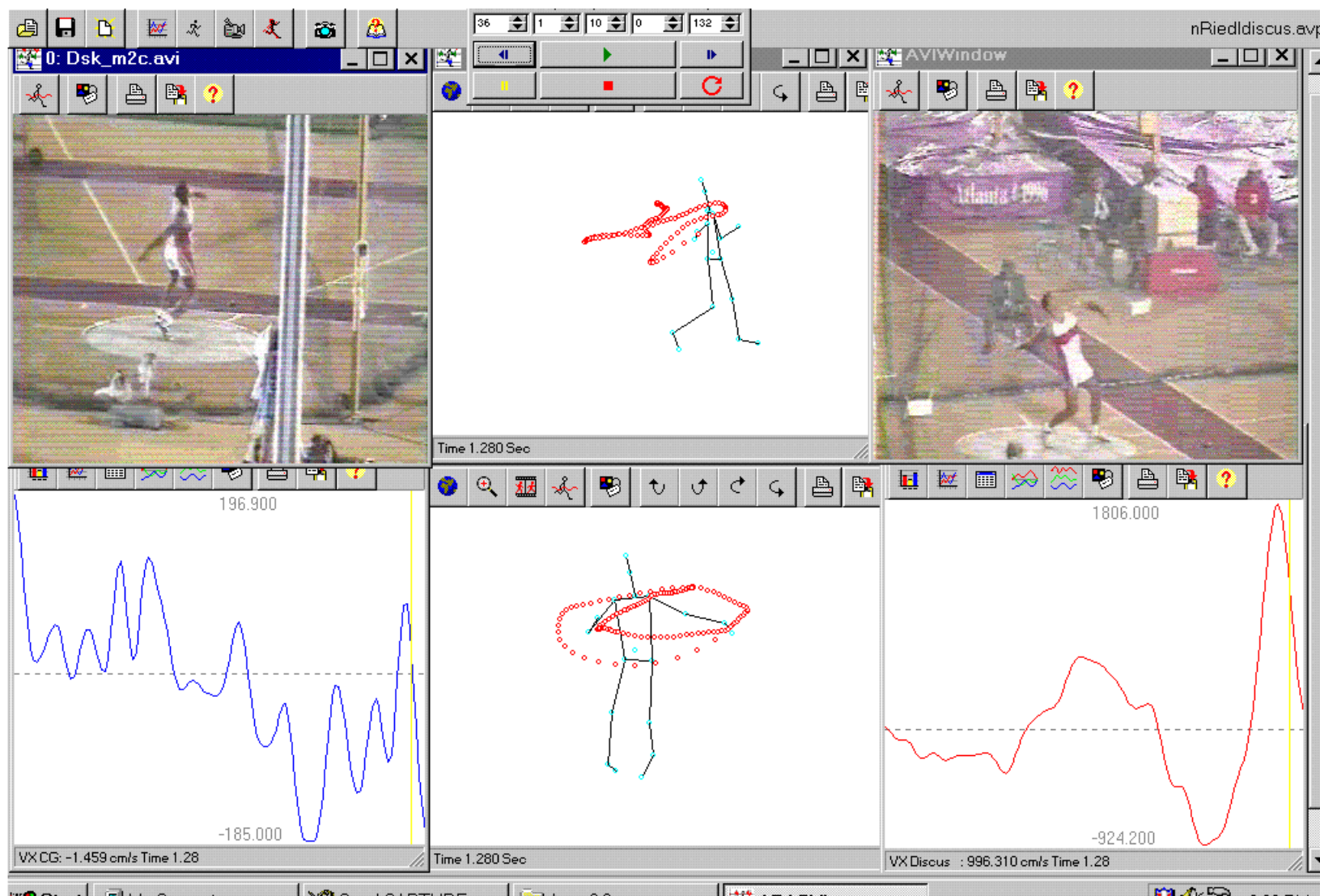
Video Recording



Video Capturing



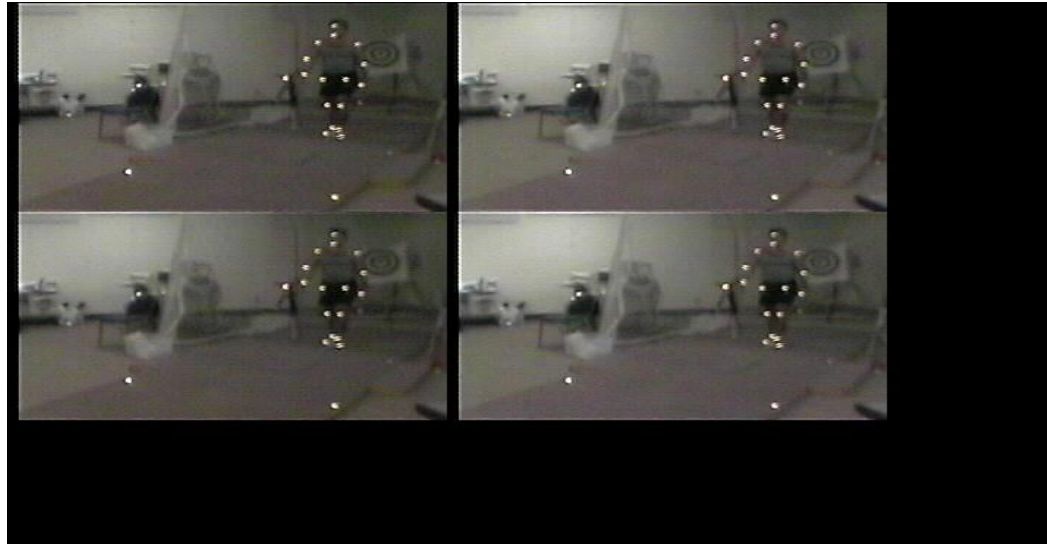
Application



Video Capturing System



Video Capturing Software Packages



Microsoft HTML
Document 5.0

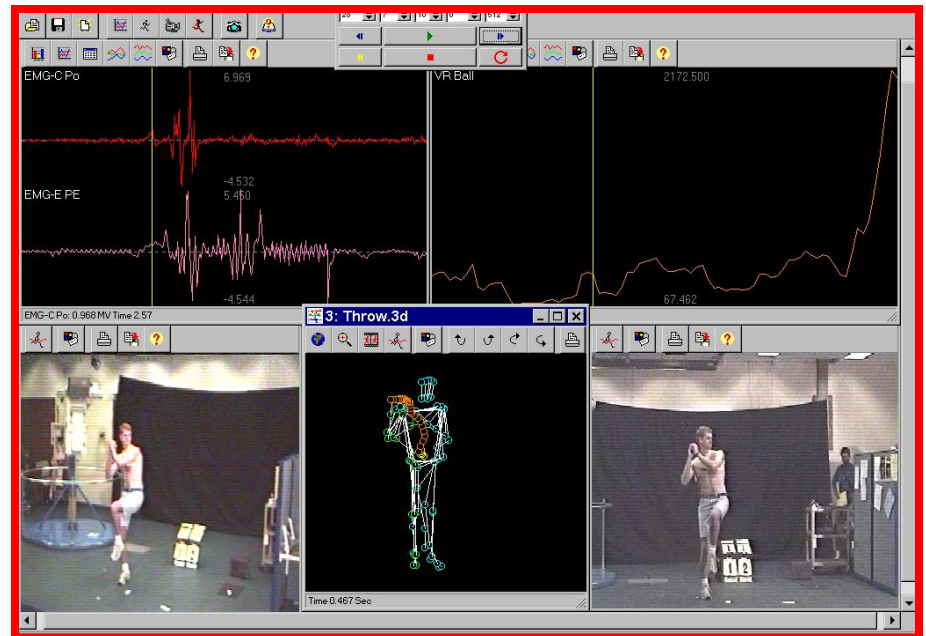


Reidel Gold Medal

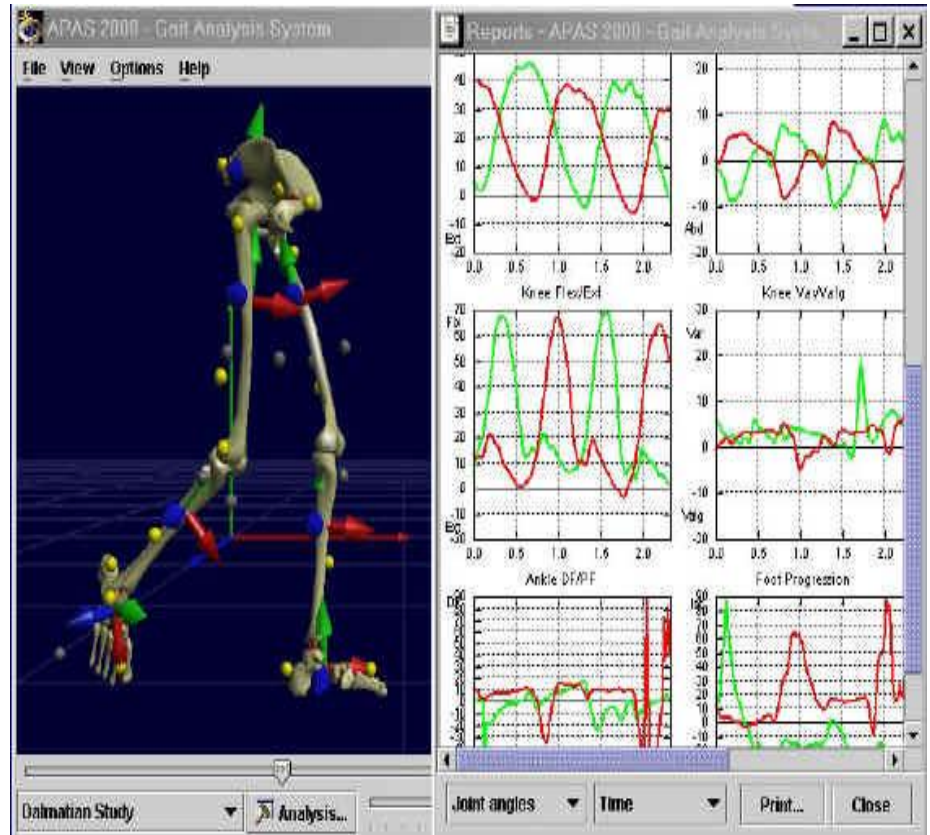
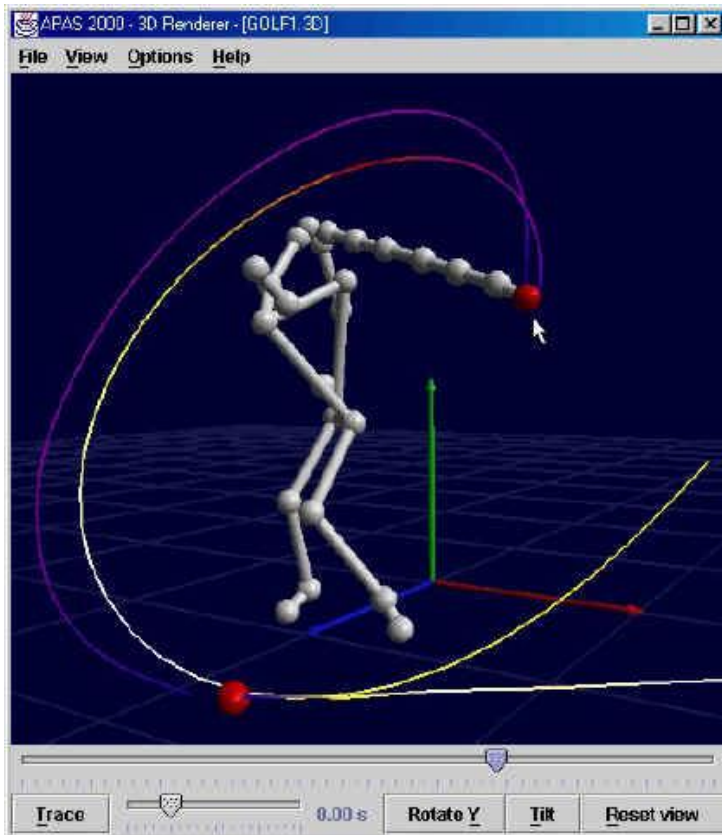


Hardware

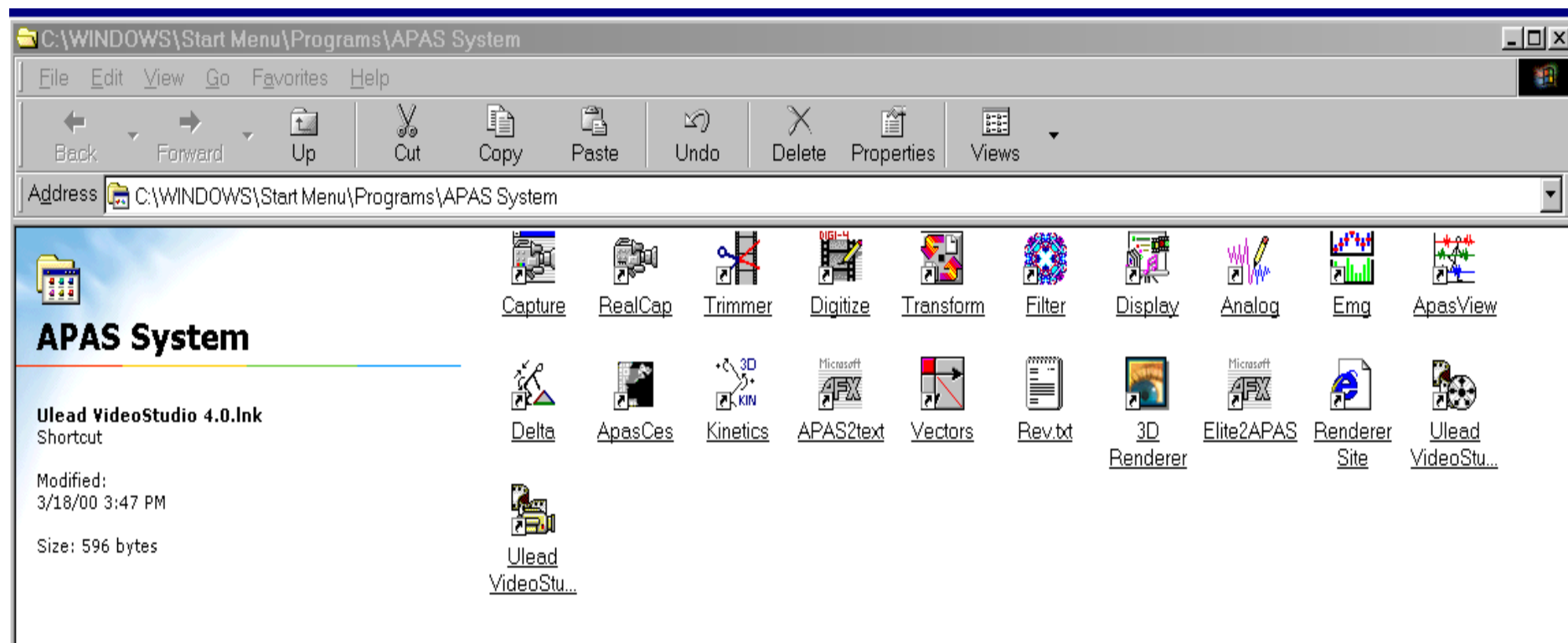
- Main Computer System
- Workstations
- Capture Card
- Network
 - Intranet
 - Internet
 - Renderer
 - Presentations



Software Integration

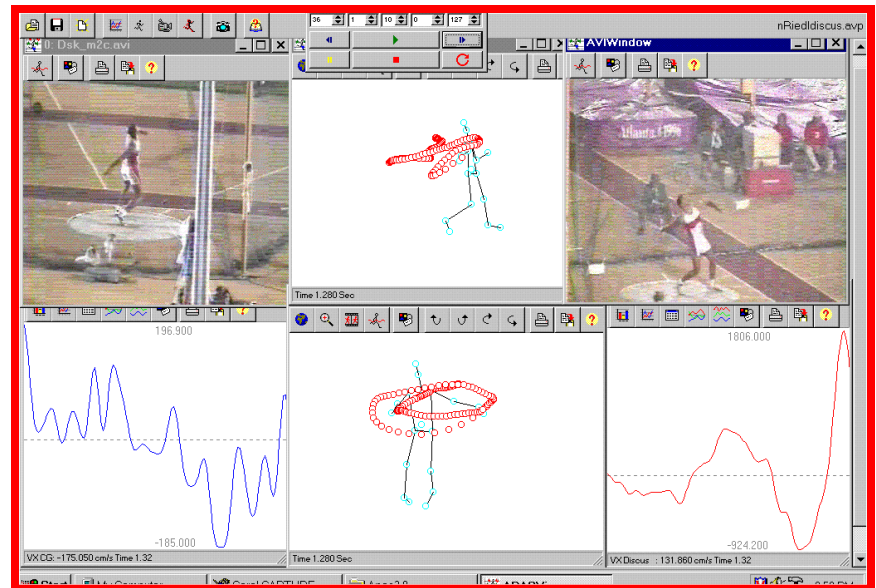


Software Modules



Software Integration

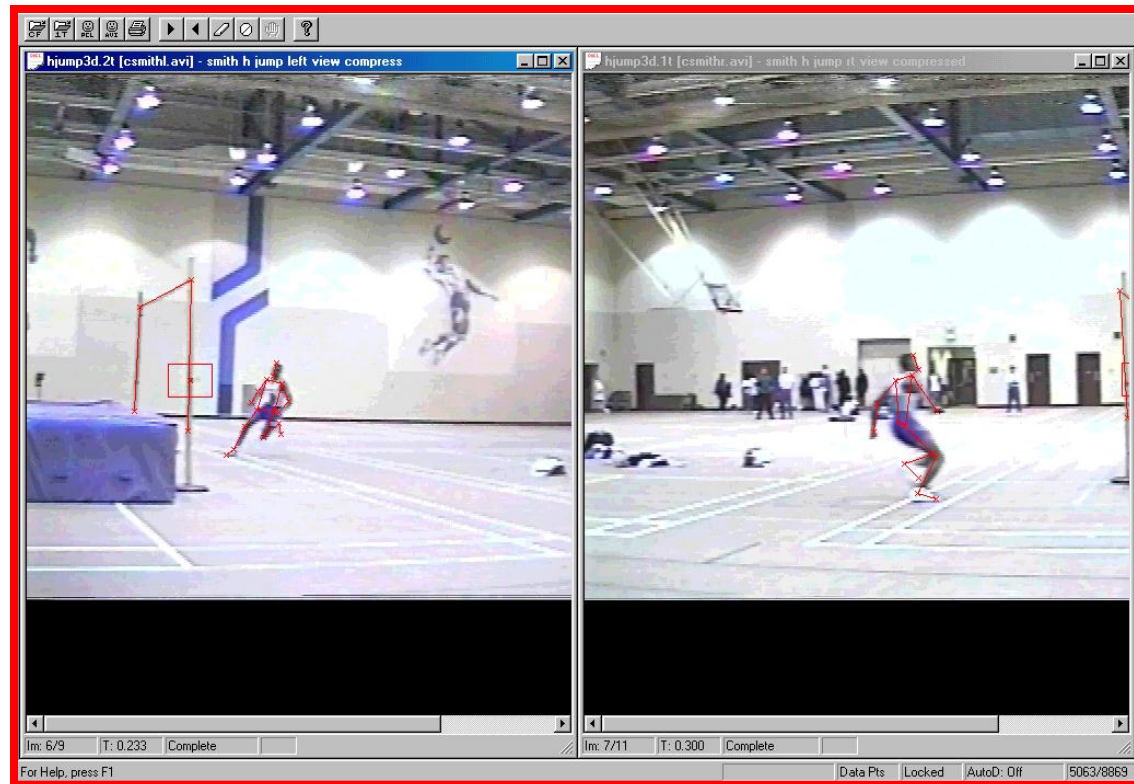
- Capturing
- Digitizing
 - Locally
 - Net Digitizing
- Transformation
- Filtering
- Kinematic Results Display
- Kinetic Results Display



Digitizing



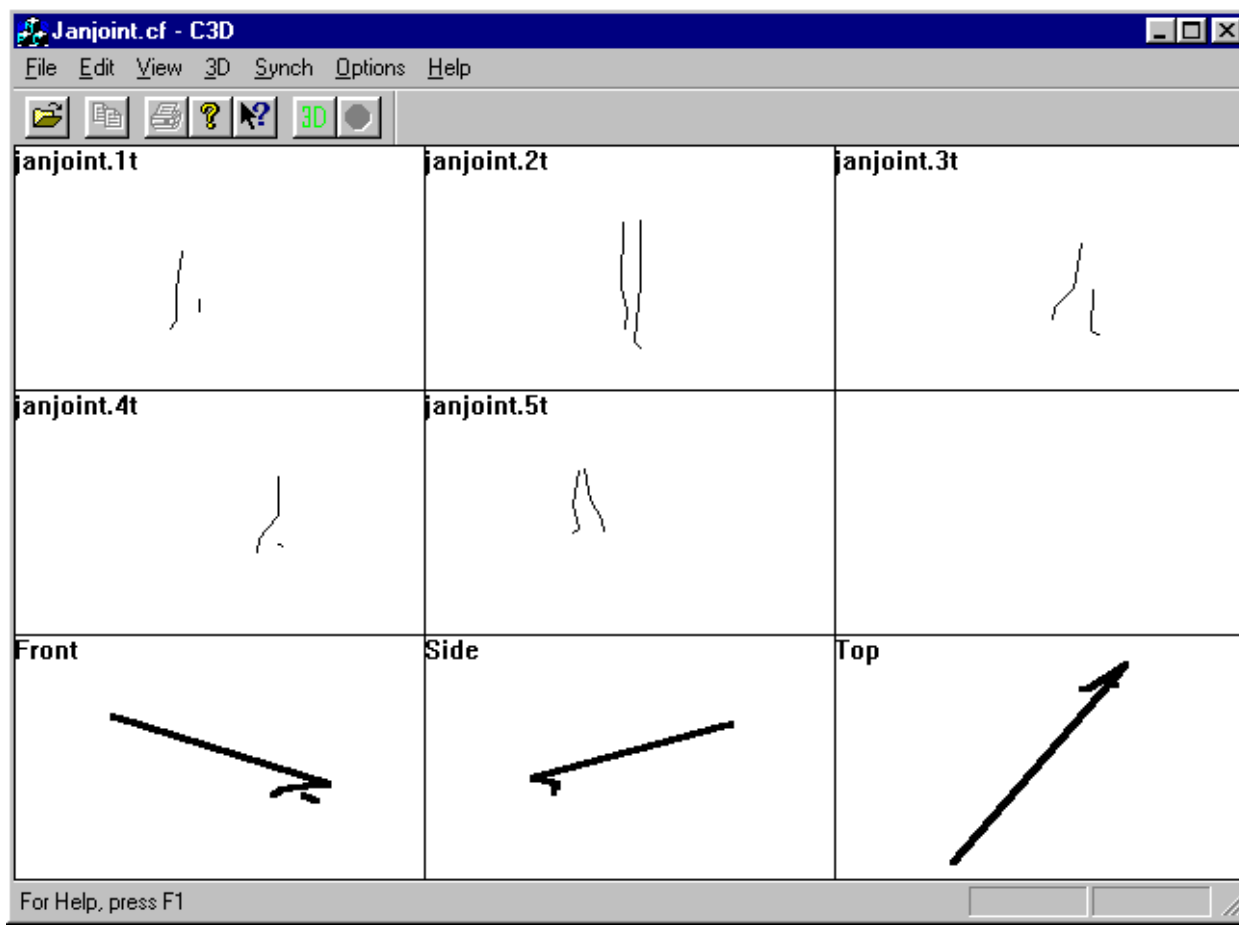
- Manually
- Automatically





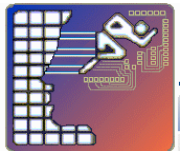
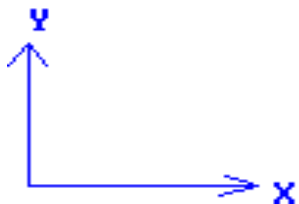
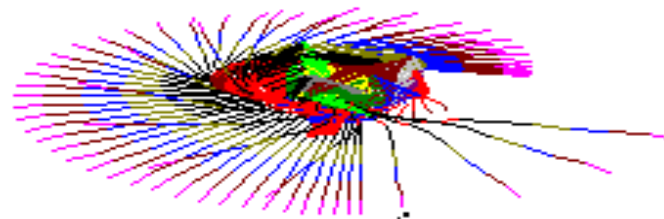
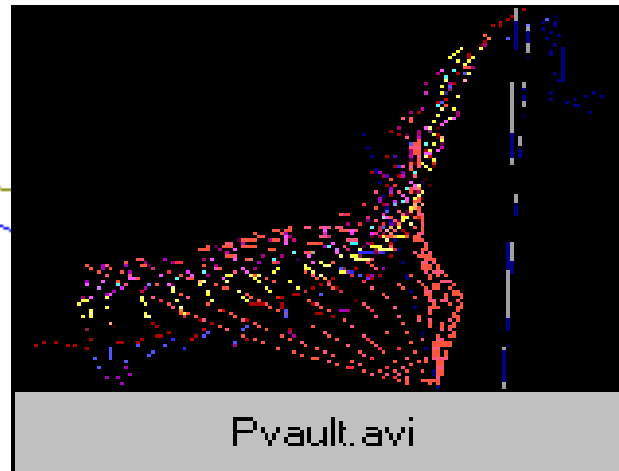
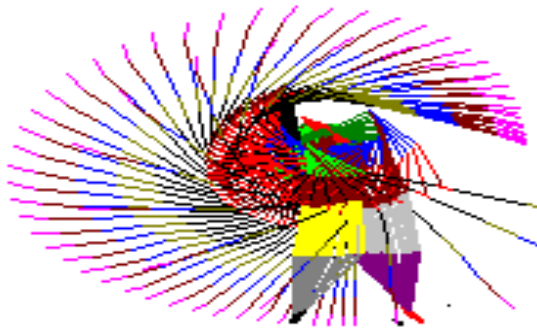
Application

Transformation

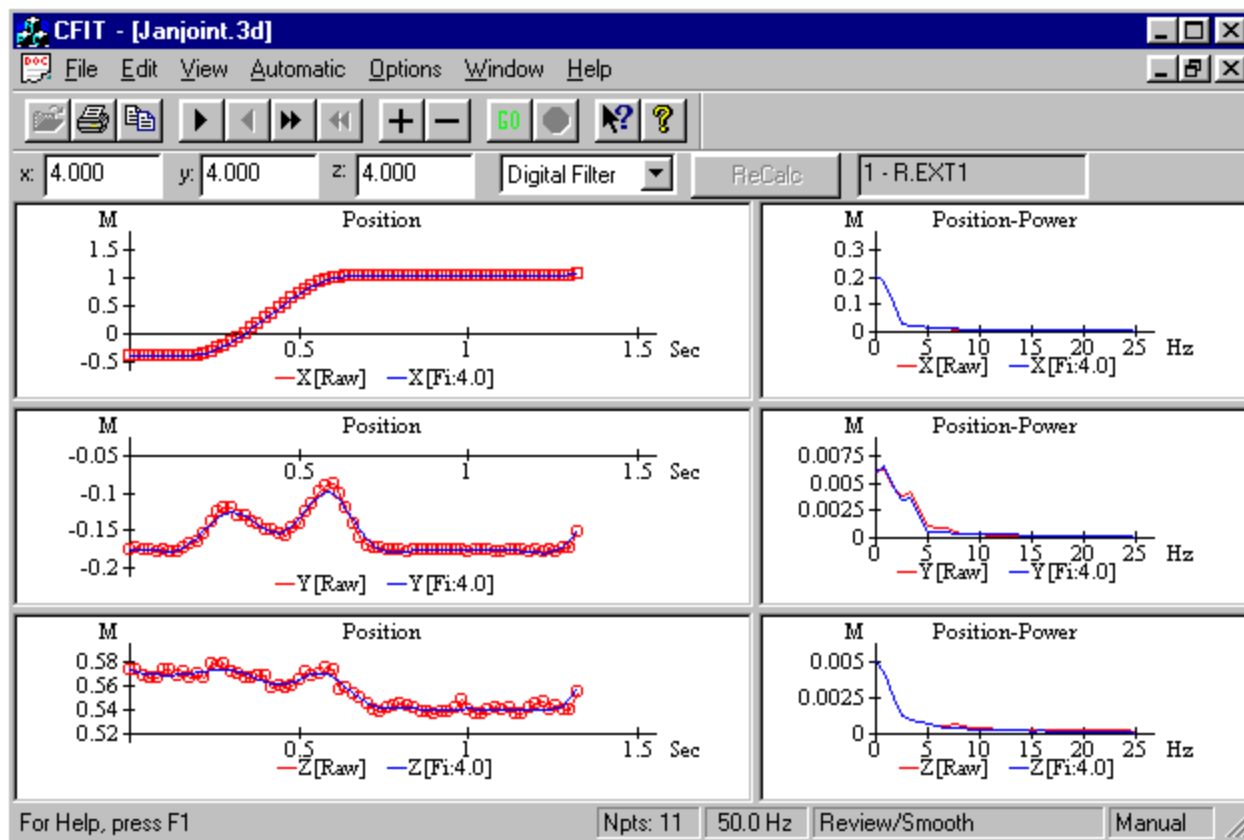


Data Transformation

VIEWING Module C.B.A. Inc.



Filtering/Smoothing




Smoothing of the Data

Filtering Algorithms

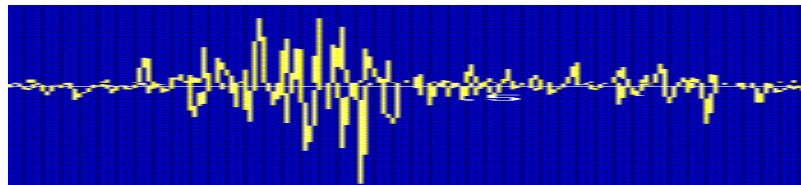
 Cubic Spline

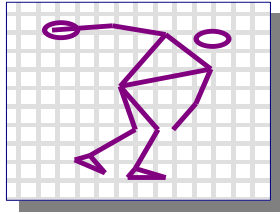
 Digital Filter

 Quintic Spline

 Fast Fourier Filter

 Segment Constraint



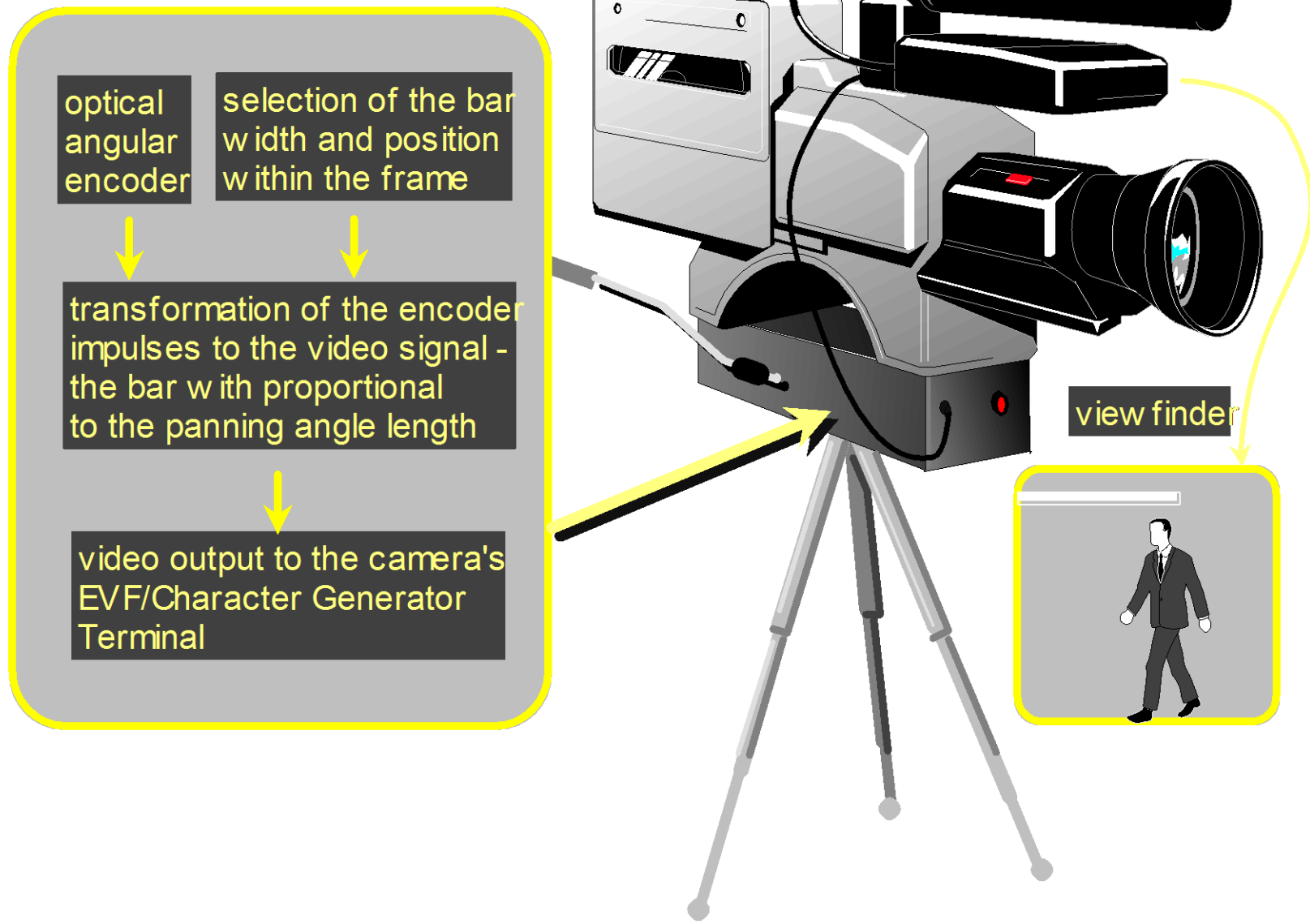


INTERNATIONAL CENTER FOR BIOMECHANICAL RESEARCH

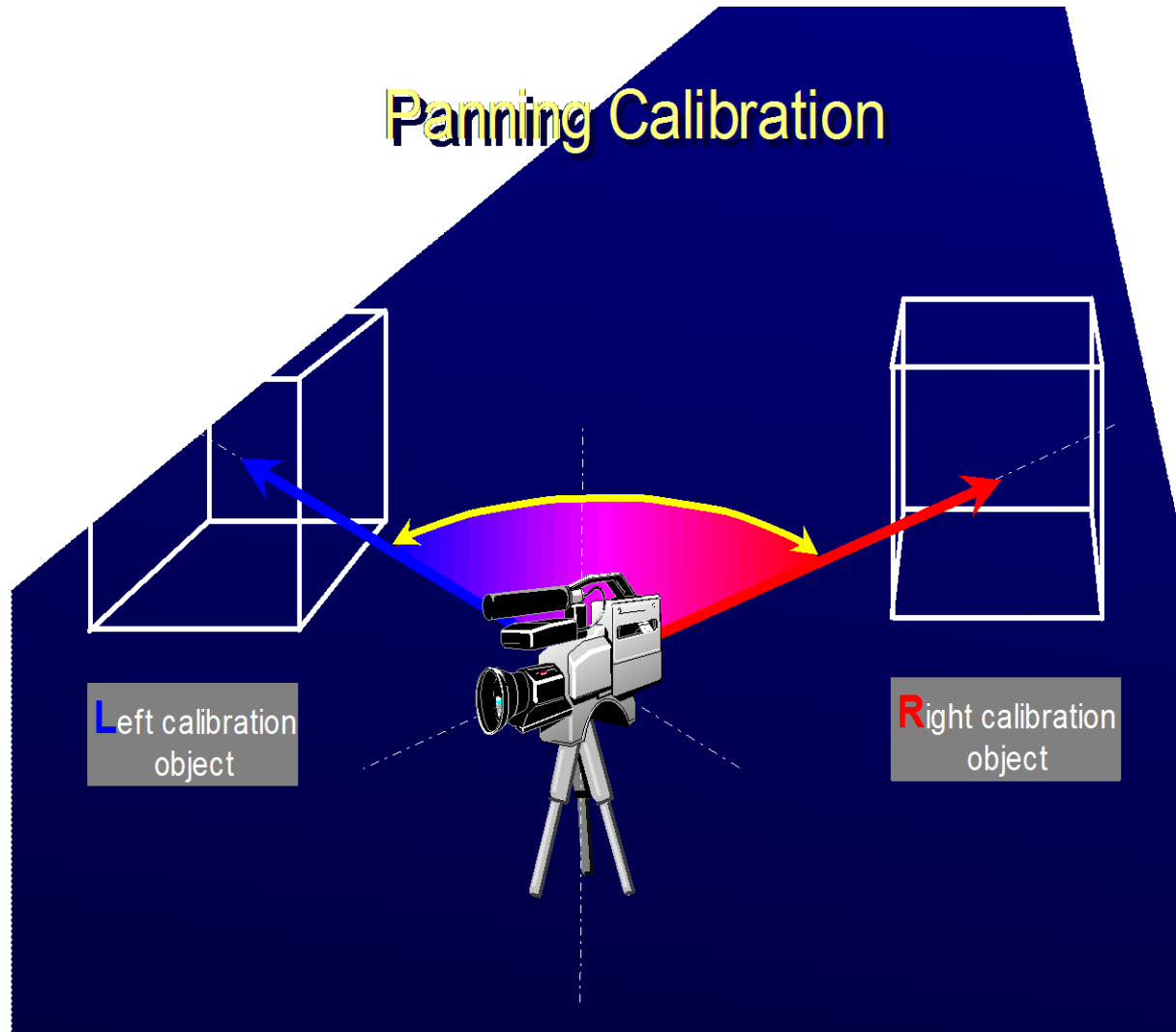
PHOTOGRAMMETRIC TRANSFORMATION WITH PANNING

**K.A. Stivers, G.B. Ariel, J. Wise, M.A.
Penny, A. Vorobiev, A. Gouskov, N.
Yakunin**

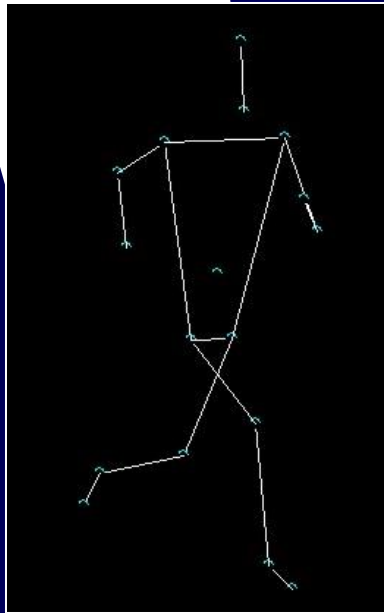
Panning Head



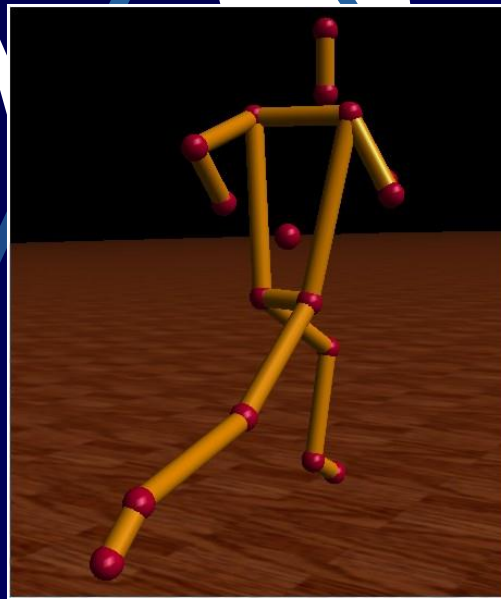
Panning Calibration



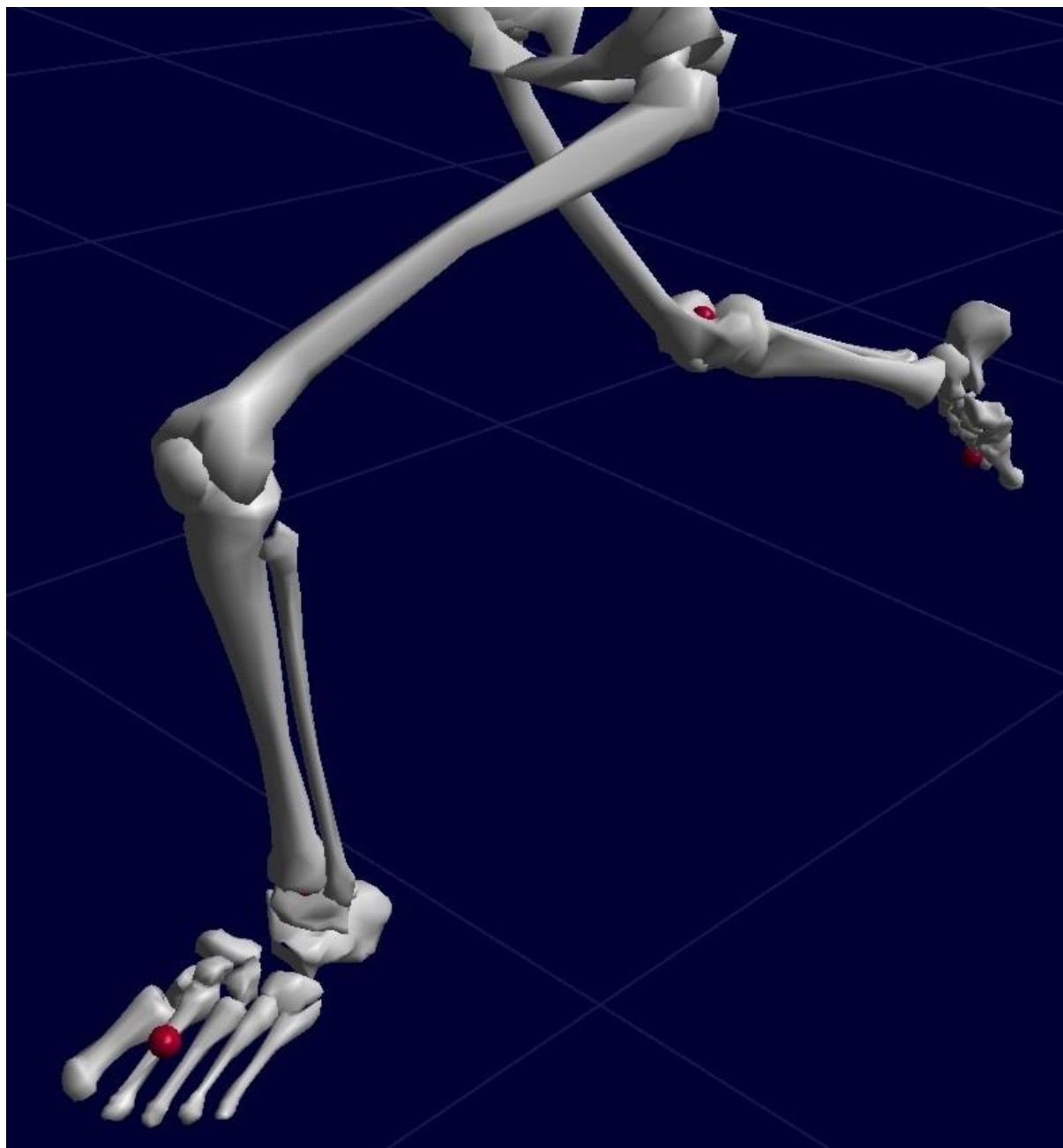
Real-time rendering

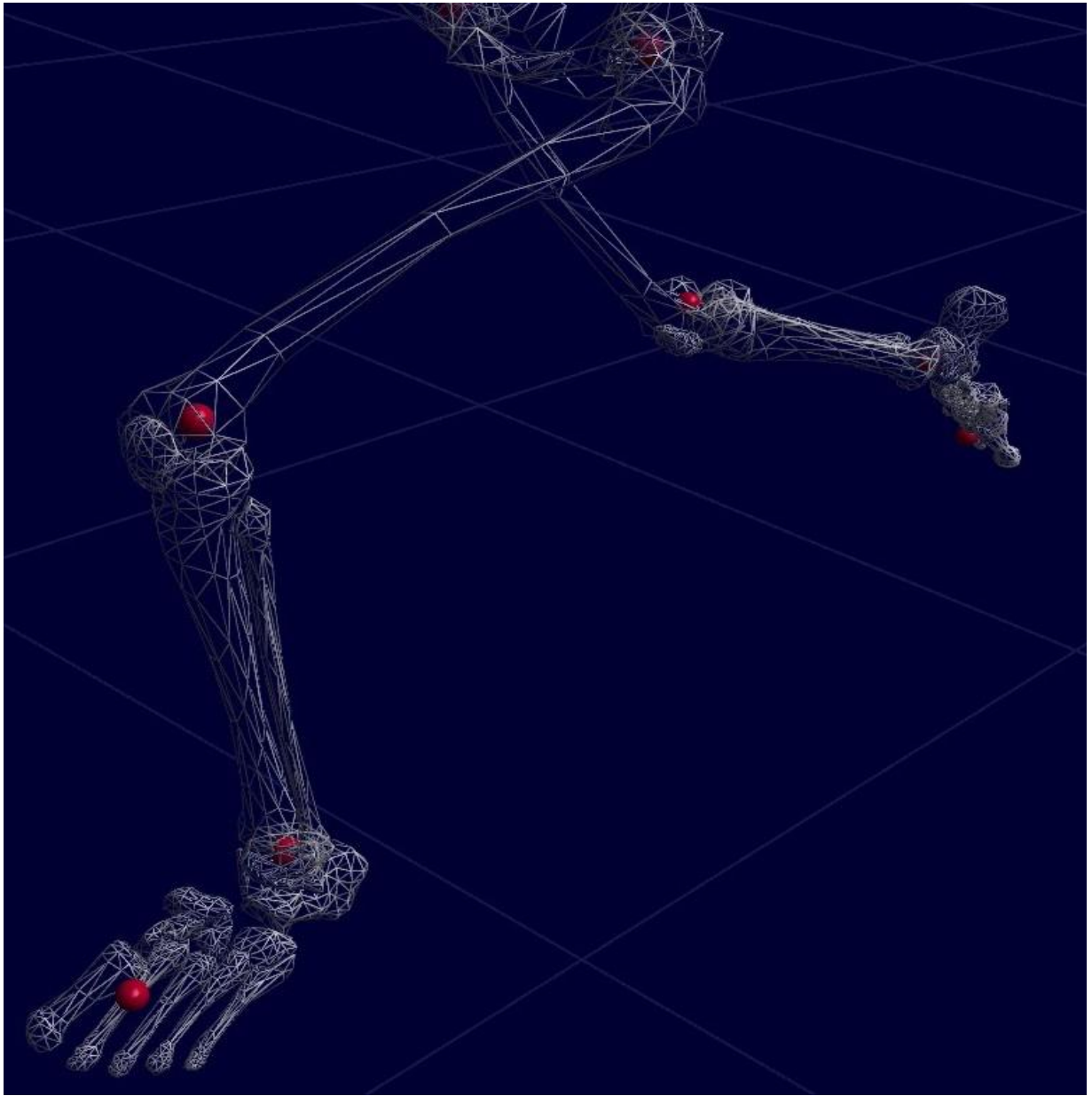


Traditional stick figure



Real-time rendering

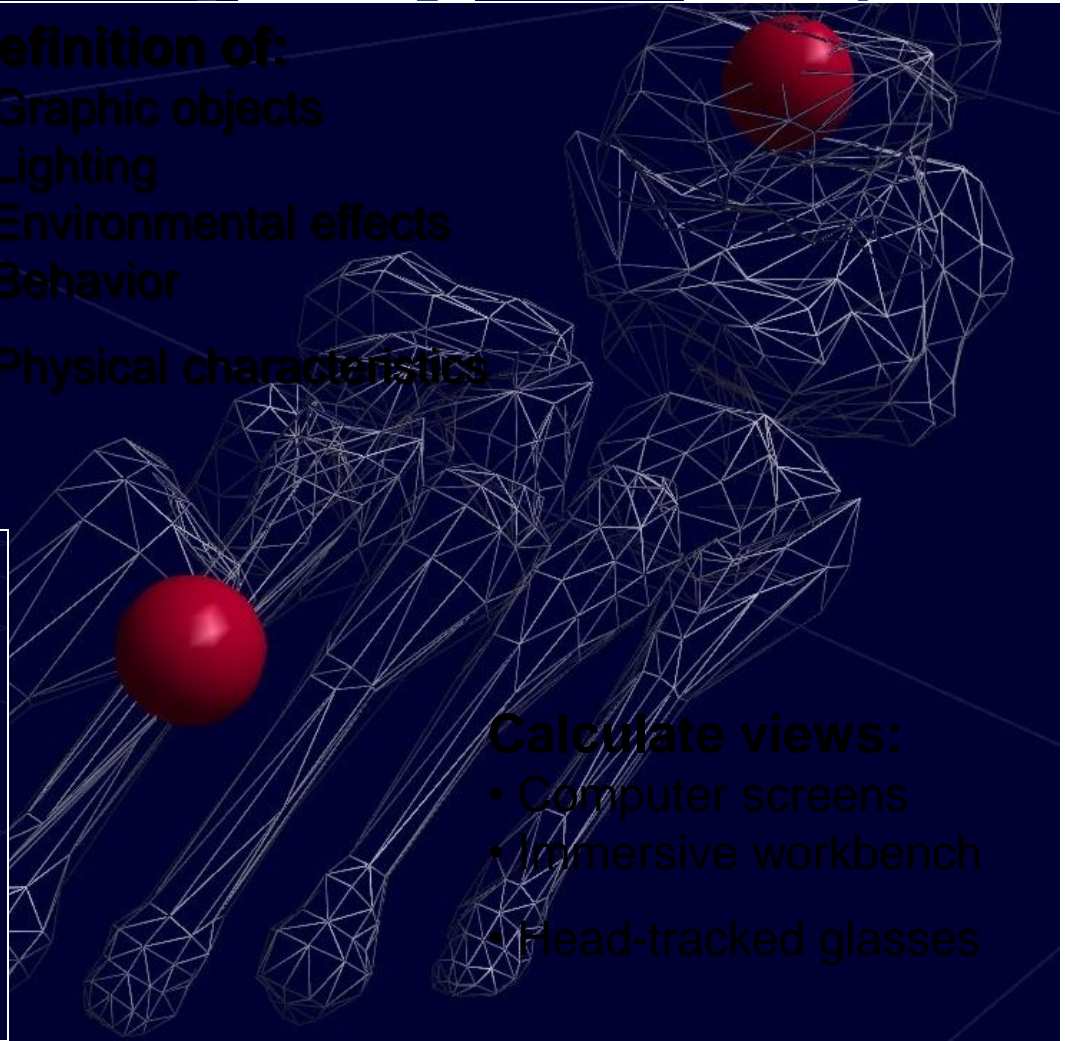
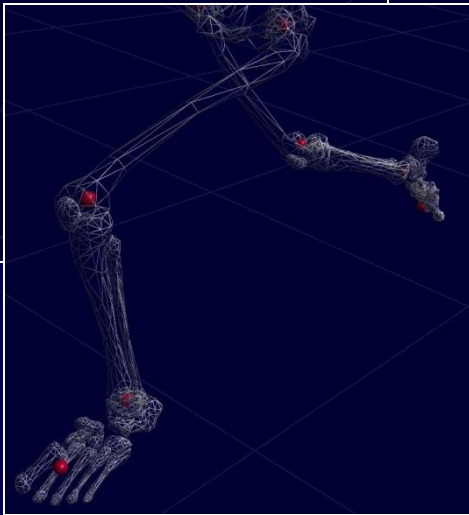
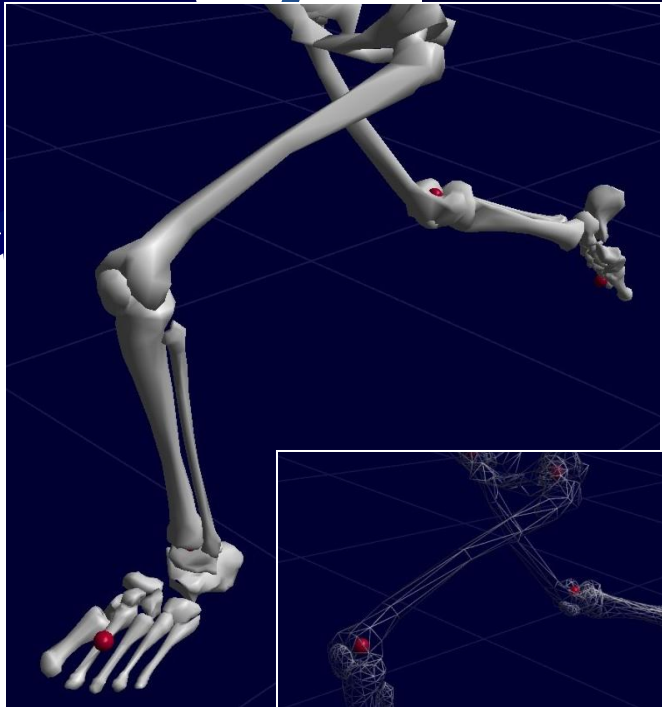




What is Rendering anyway?

Definition of:

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

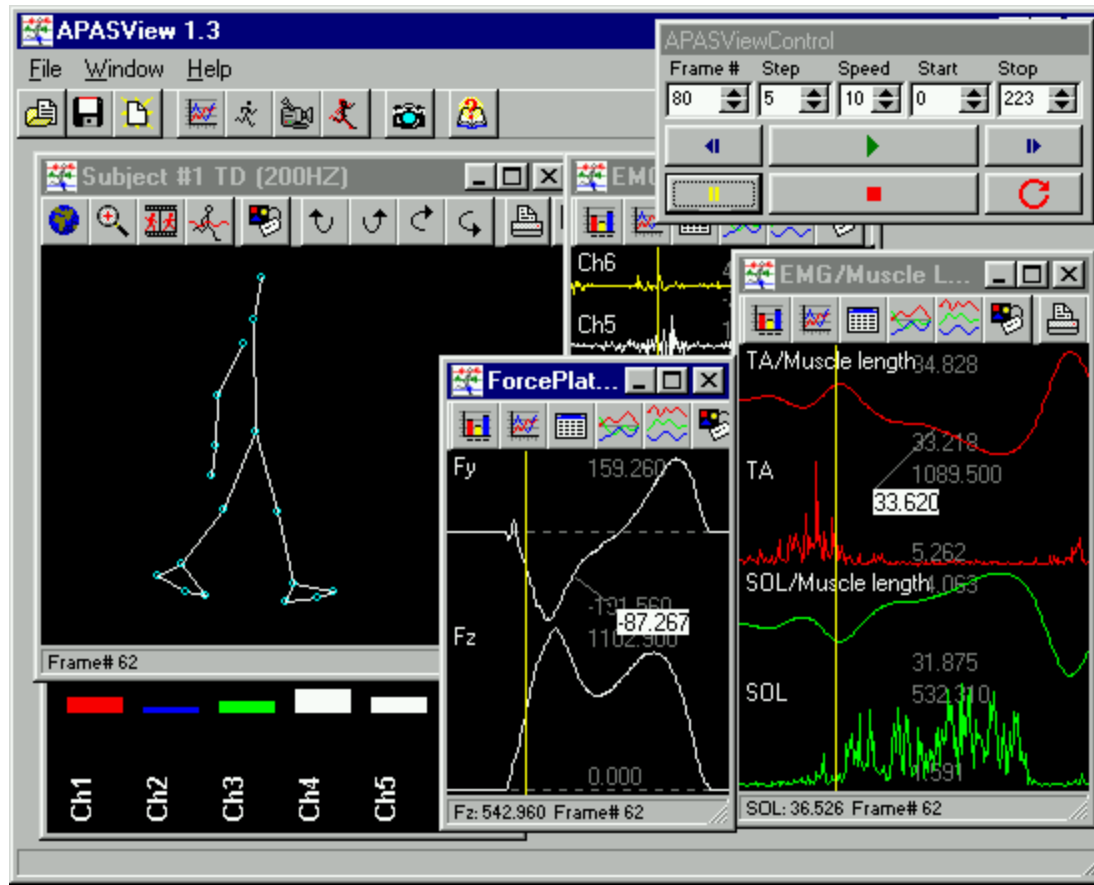


Calculate views:

- Computer screens
- Immersive workbench
- Head-tracked glasses

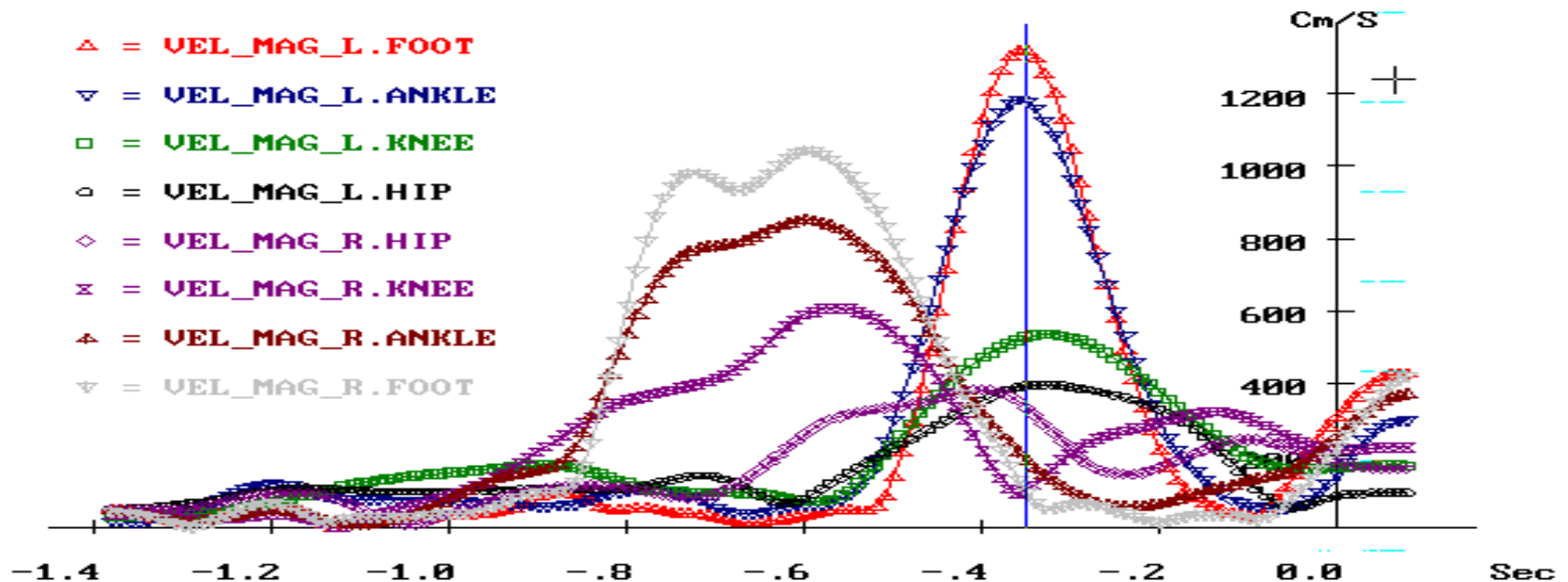


Display and Analysis

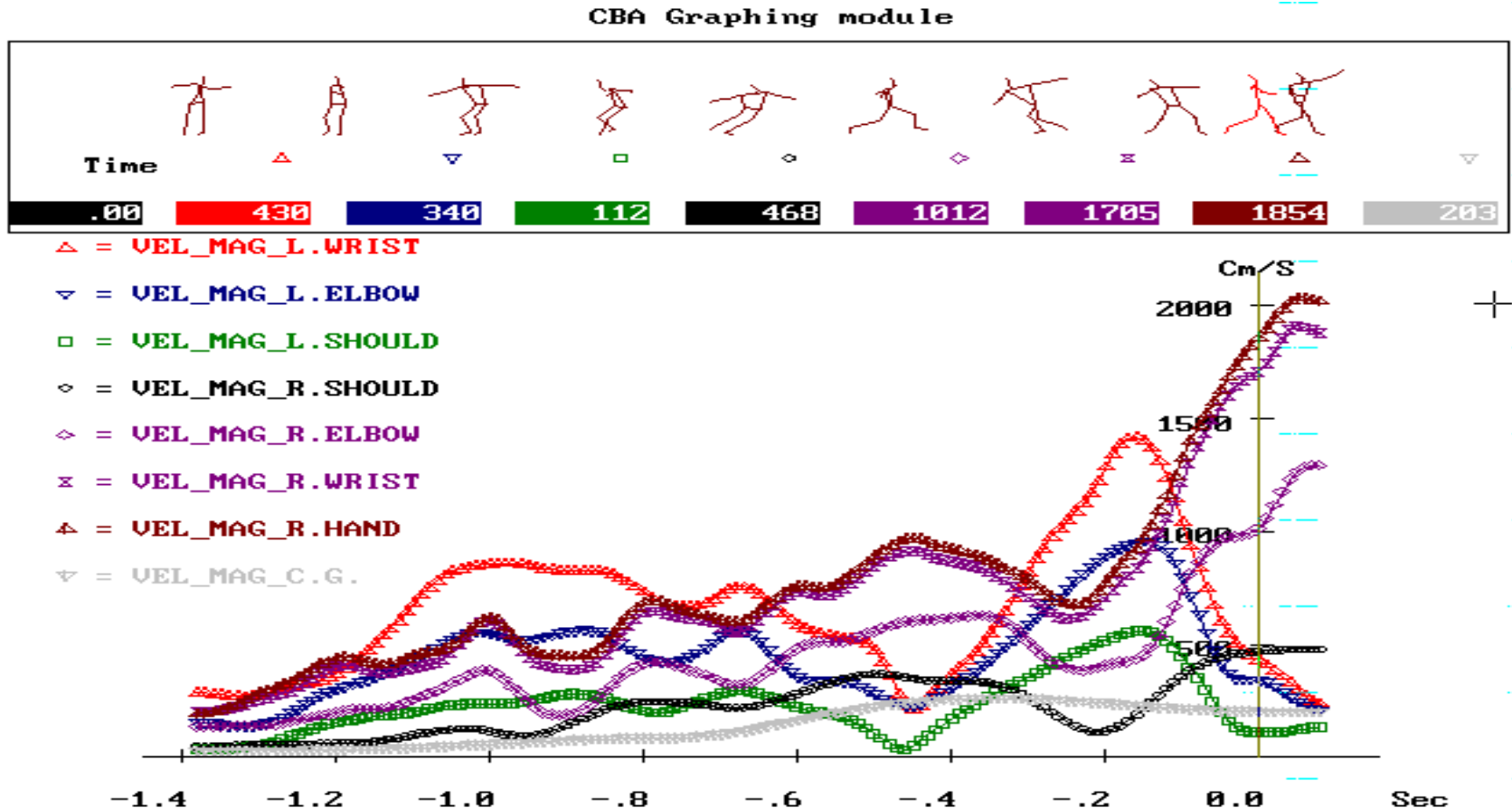


Calculating the Velocities of the lower limb revealed acceleration and deceleration patterns in a unique sequence

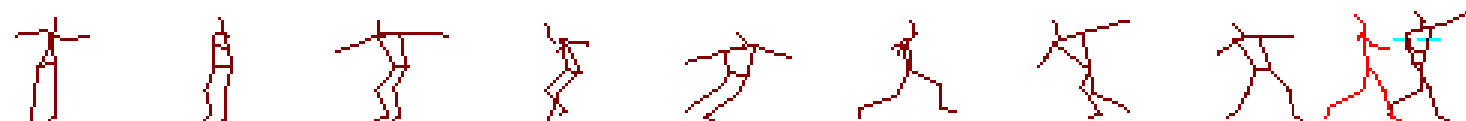
CBA Graphing module



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

-0.8

-0.6

-0.4

-0.2

0.0

Sec

****Enter Root Filename [8 Chars]****

Filename: **dub2vel**

Enter-Select

CBA Graphing module



Time

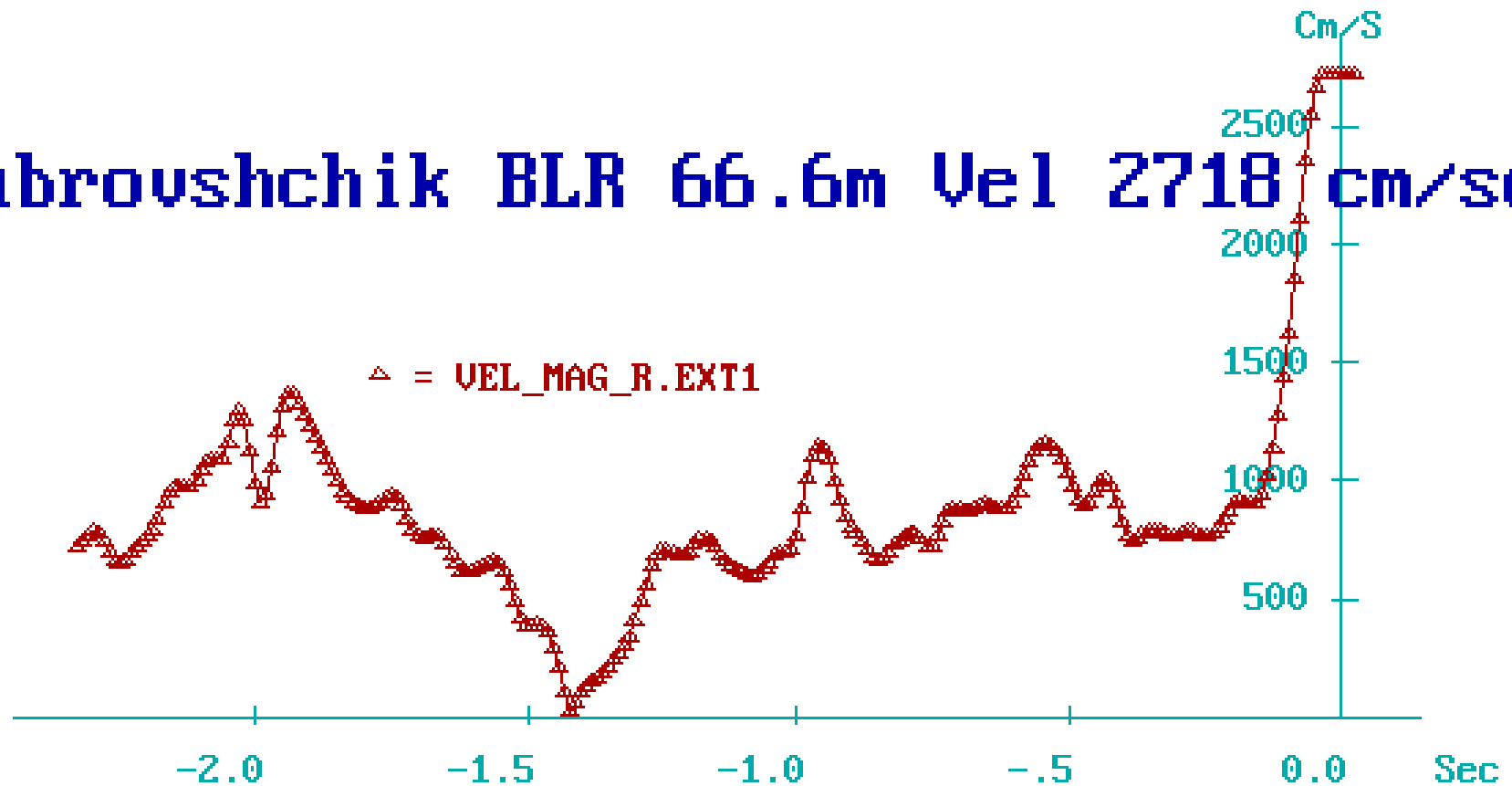
-.003

Δ

2718.419

Dubrovshchik BLR 66.6m Vel 2718 cm/sec

Δ = VEL_MAG_R.EXT1



****File Exists****

Replace **Keep**

F10-Quit

CBA Graphing module



Time

-.046

△

2126.684

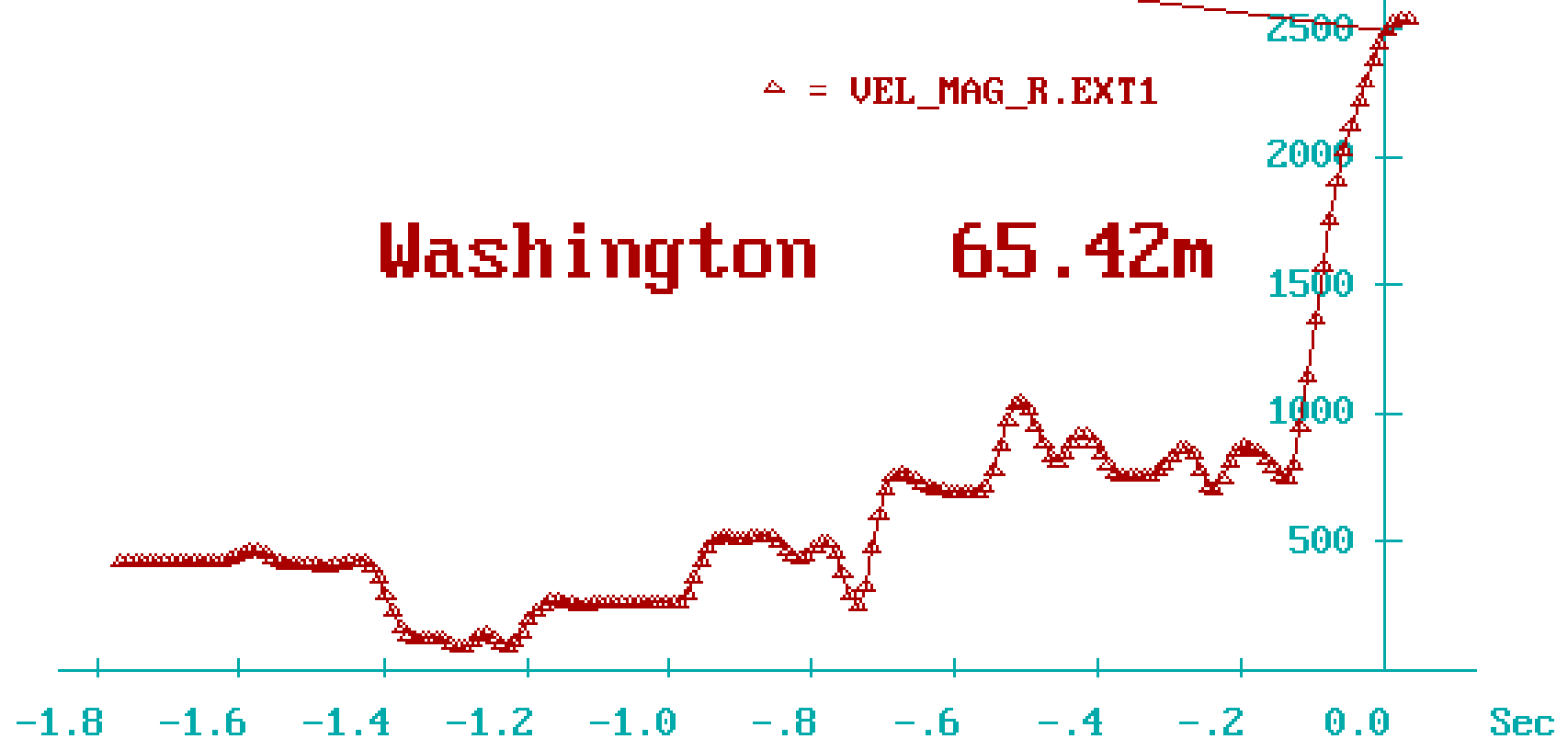
2484.85

Cm/S

△ = VEL_MAG_R.EXT1

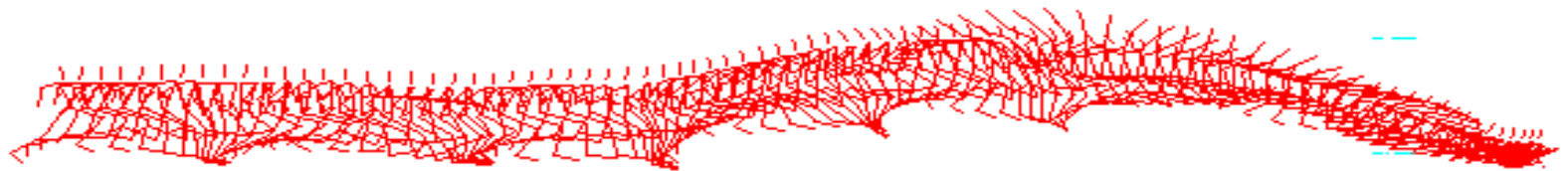
Washington

65.42m

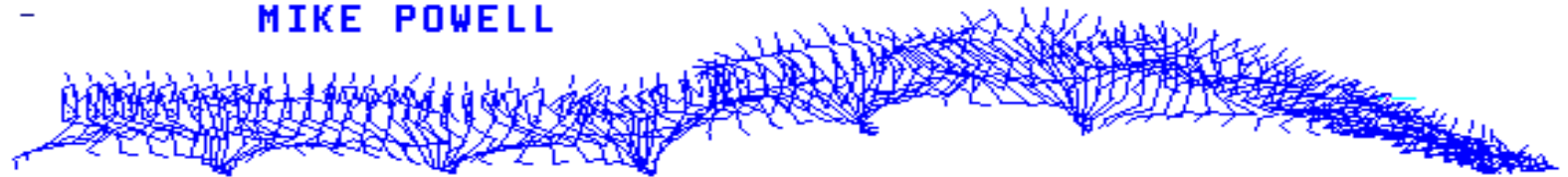


THE CASE OF THE LONG JUMP:

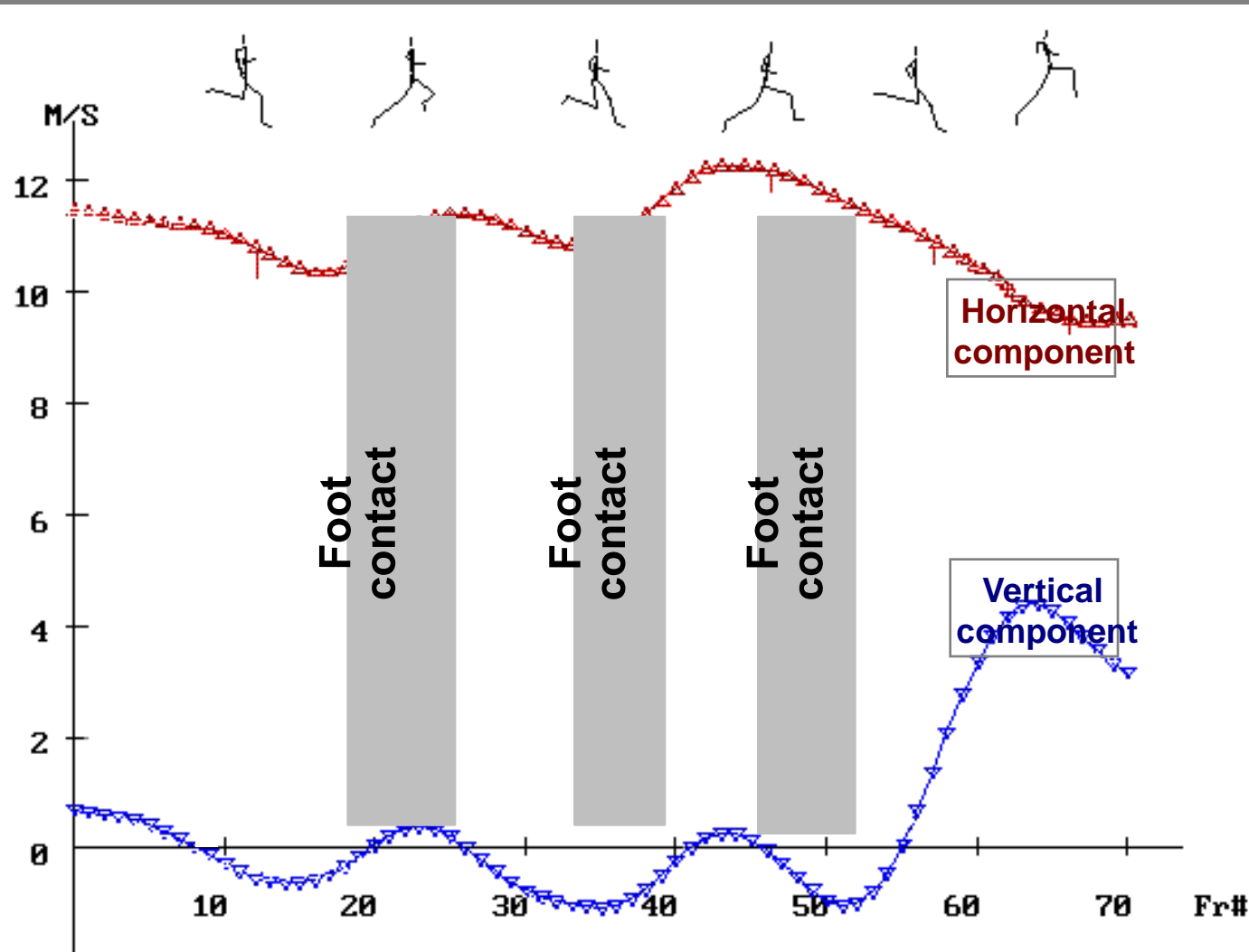
CARL LEWIS



MIKE POWELL



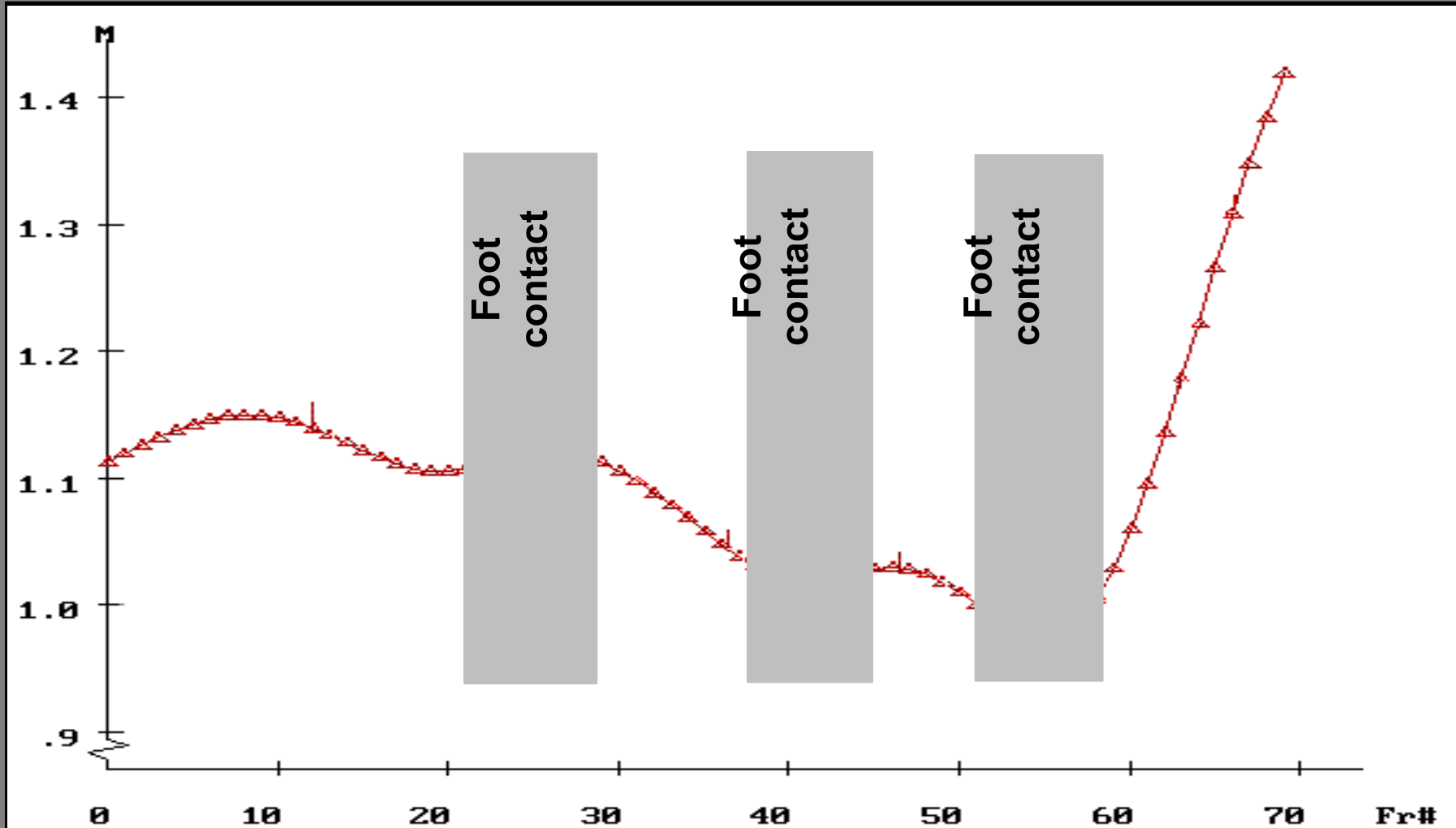
Velocity of the Center of Mass



Mike Powell 8.95m - World Record

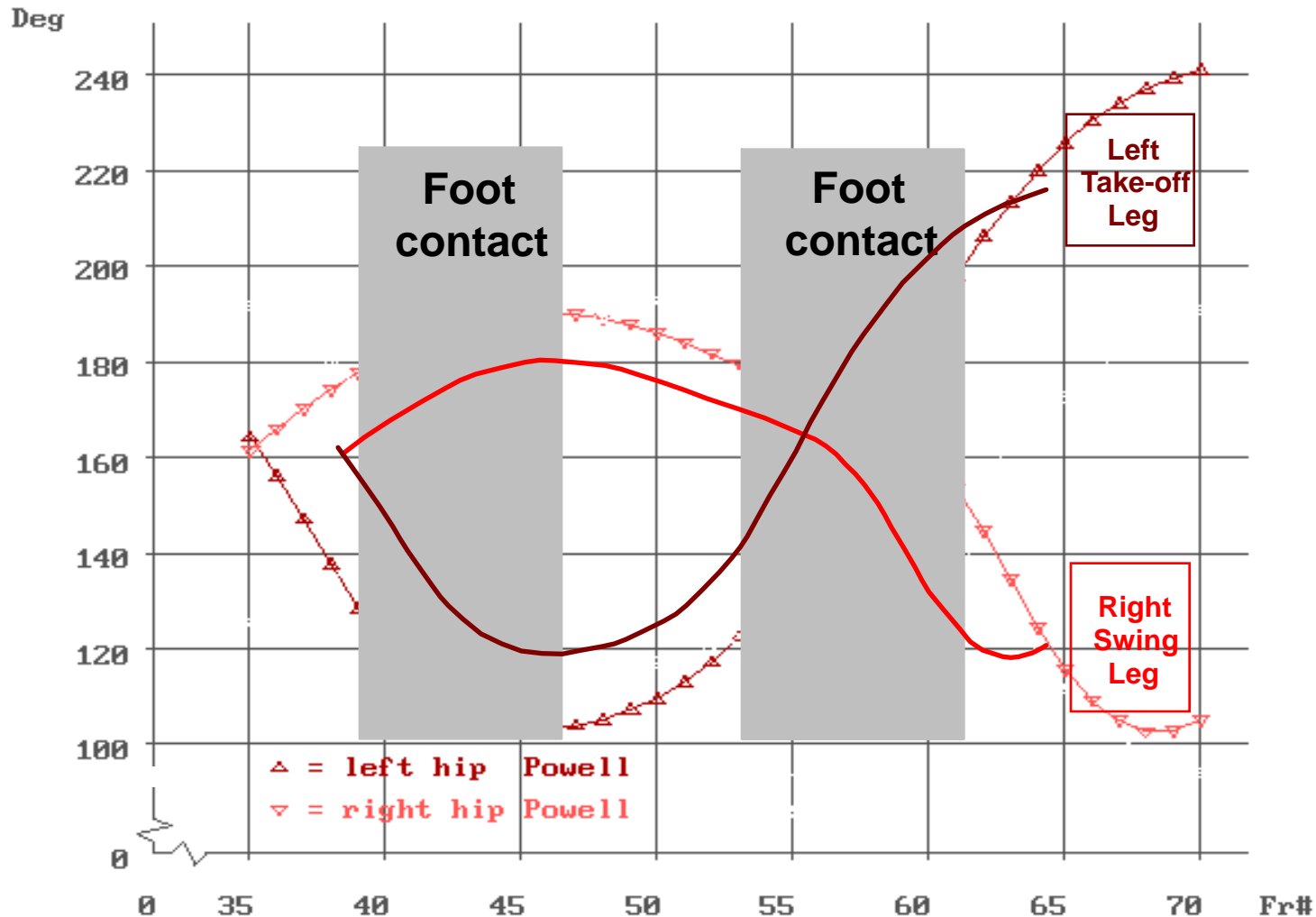


Height of the Center of Mass



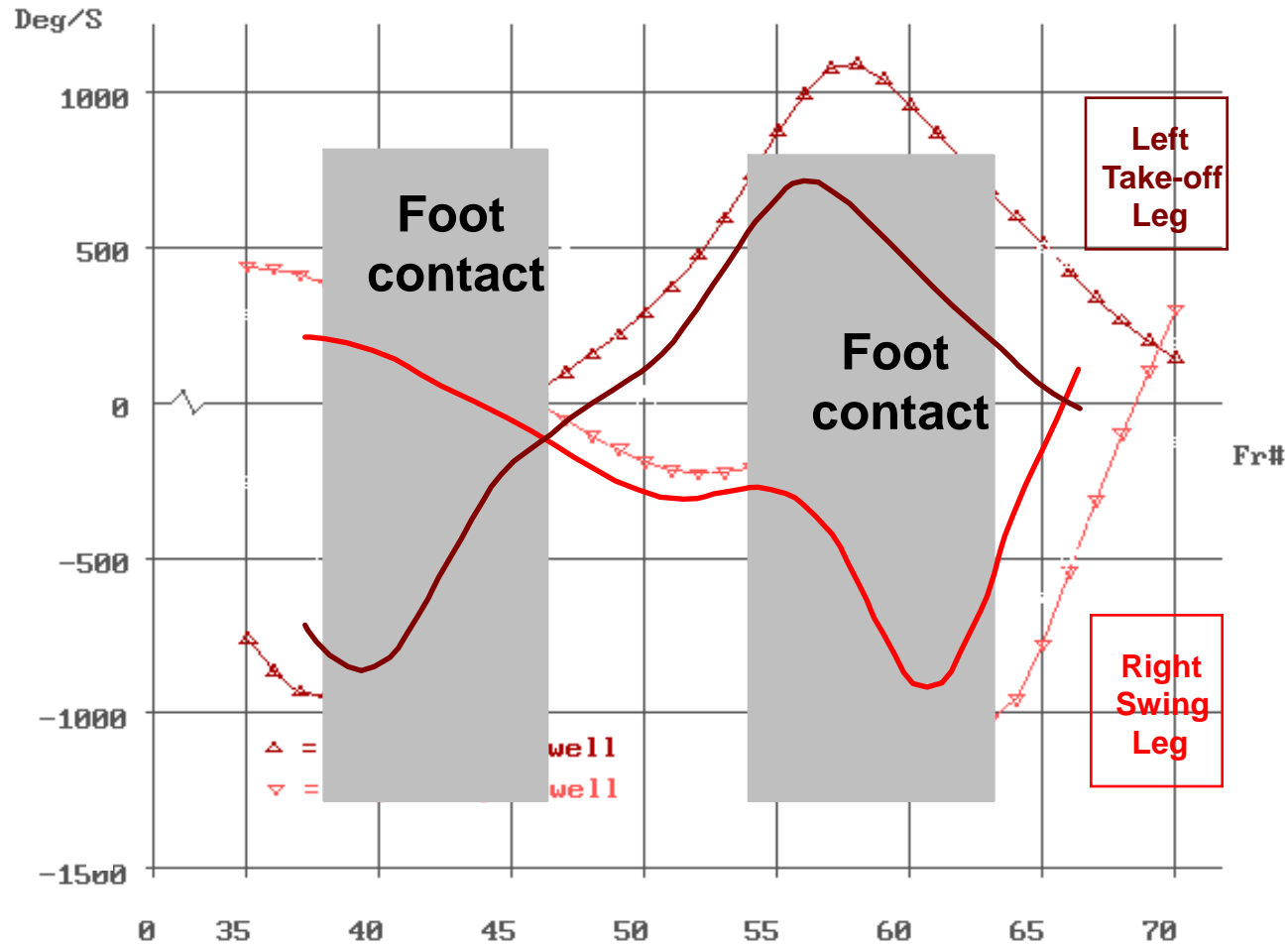
Mike Powell 8.95m - World Record

Angular Displacement in Hip Joints



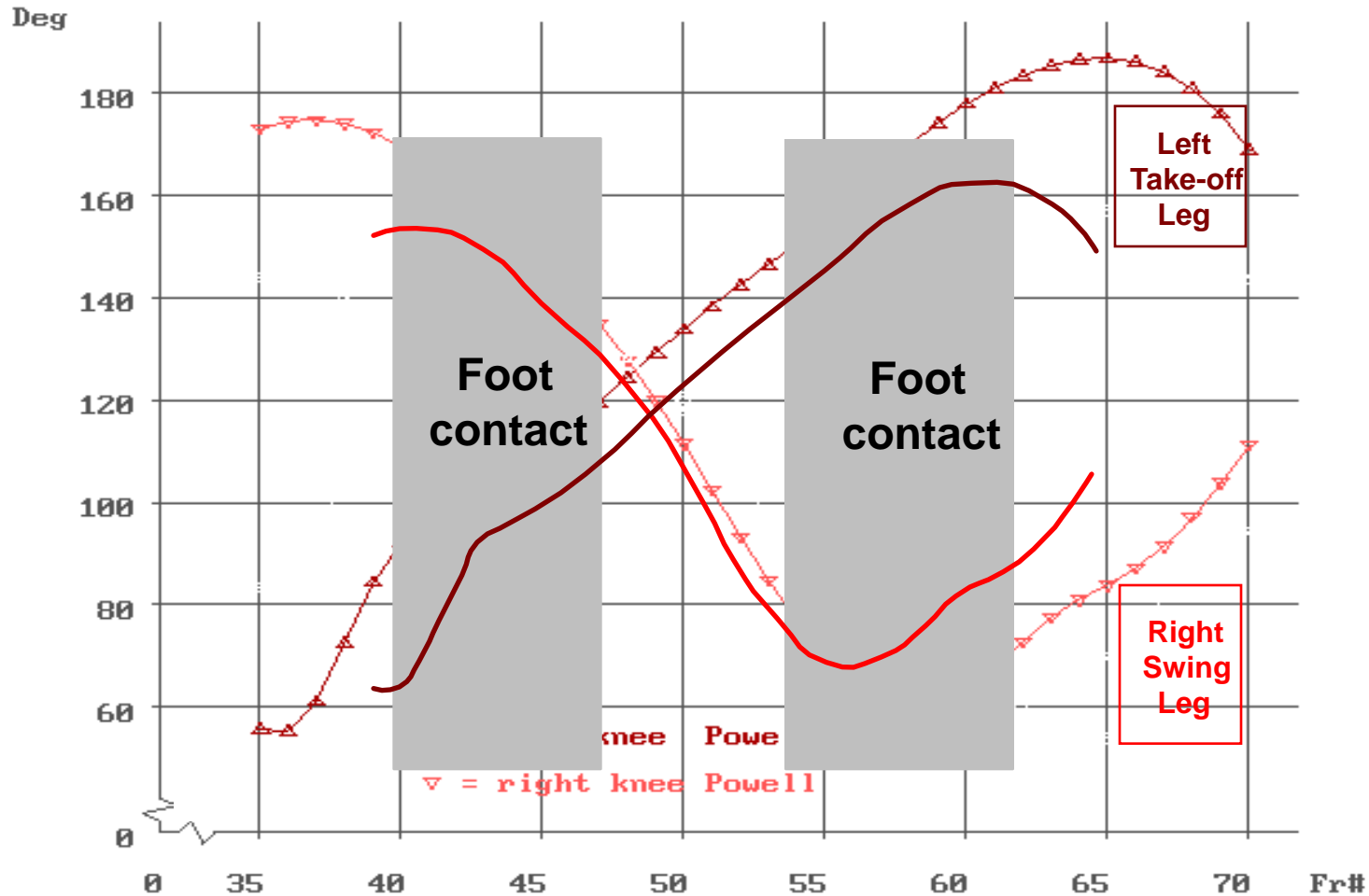
Mike Powell 8.95m - World Record

Angular Velocity in Hip Joints



Mike Powell 8.95m - World Record

Angular Displacement in Knee Joints



Mike Powell 8.95m - World Record

KINETIC FORCE PLATE GROUND REACTION FORCES



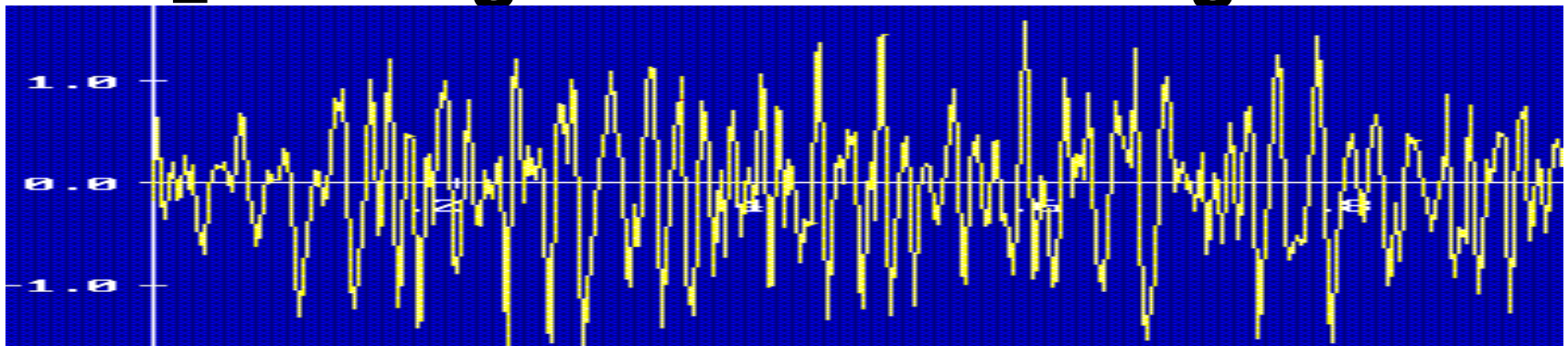
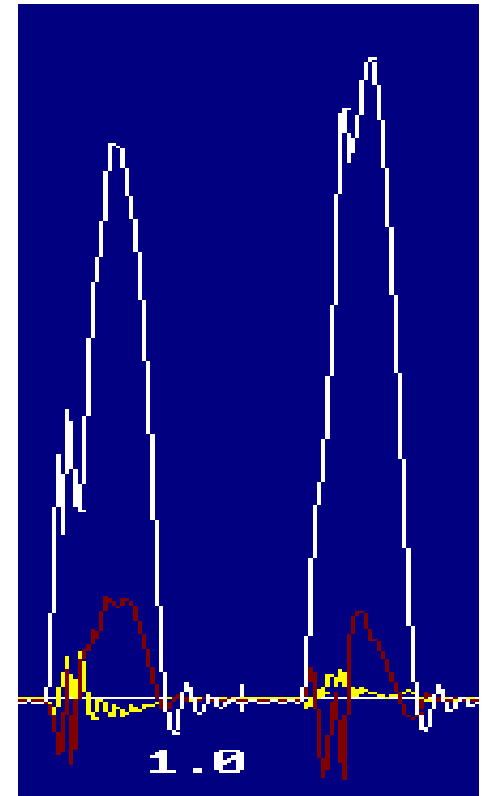
Analog Data Input

Force Plates

-  Horizontal force
-  Lateral force
-  Vertical force

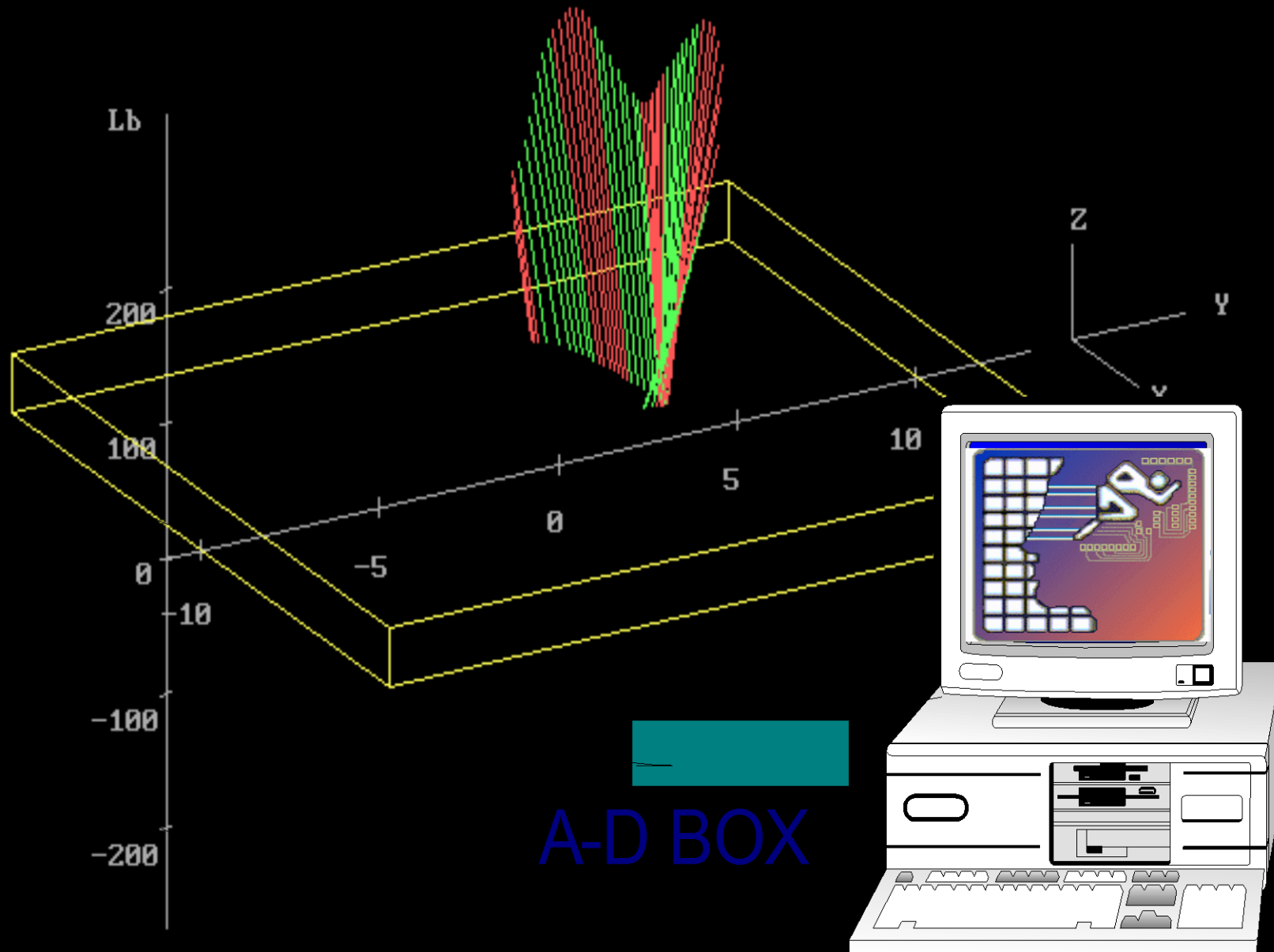
EMG Data

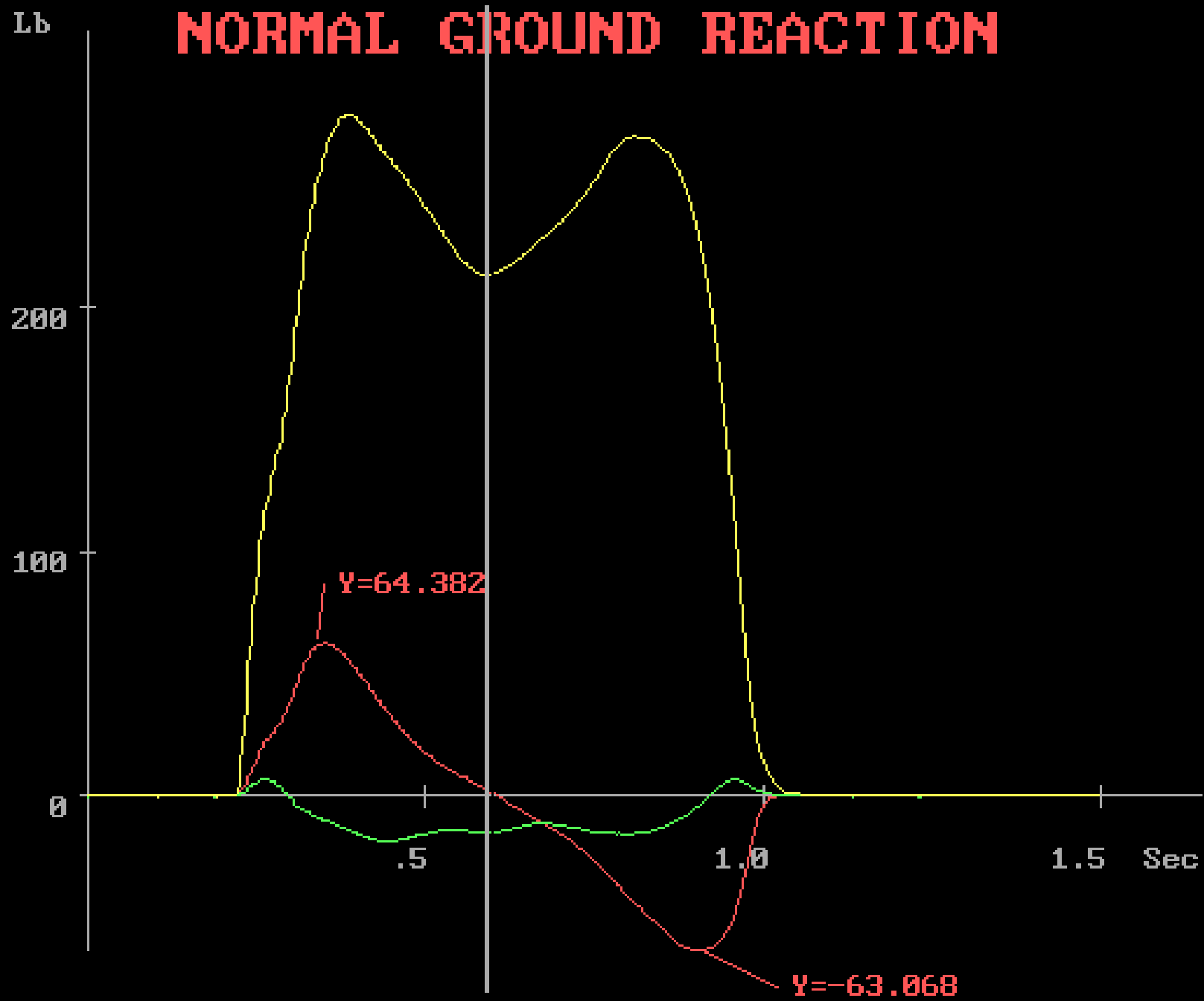
-  Muscle Activity
-  Timing of Muscular firing



CBA Analog Module

FORCE PLATE



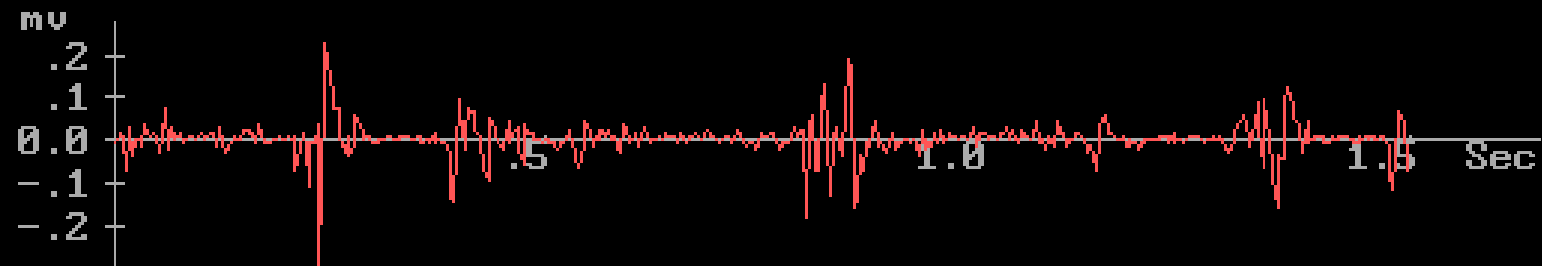


CBA Analog Module

I=RULP



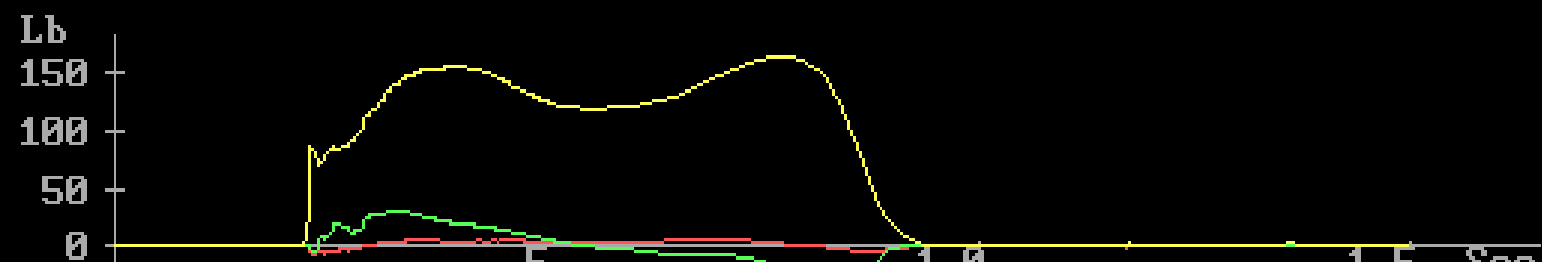
J=RLLP



K=LULP



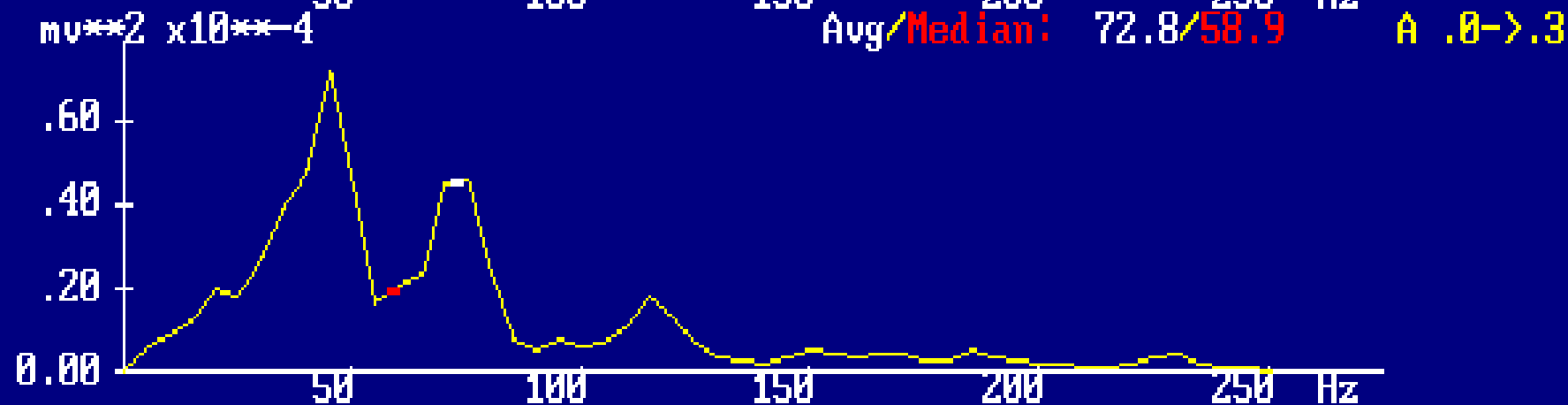
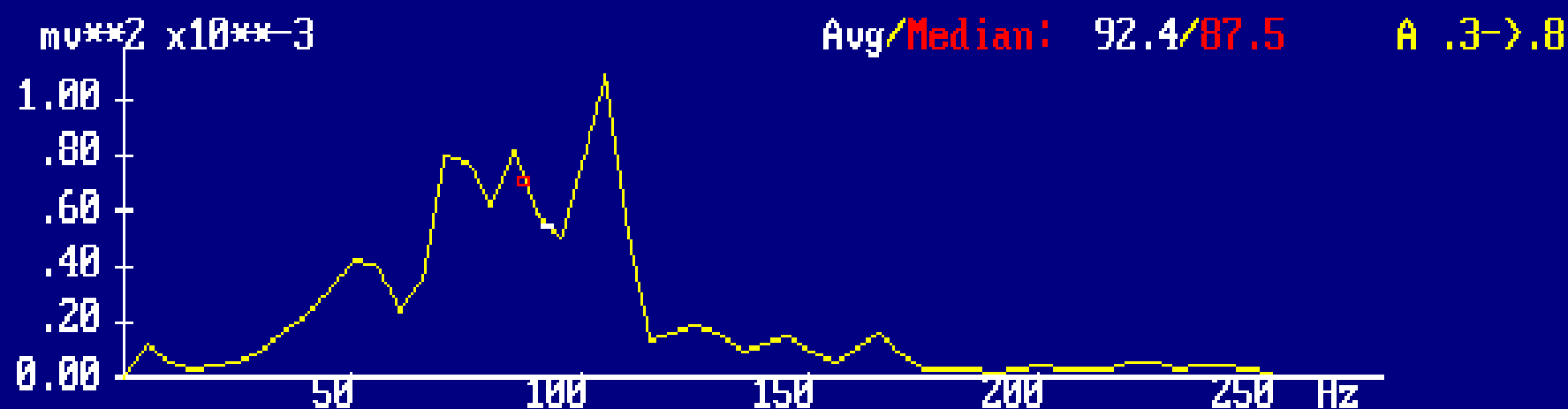
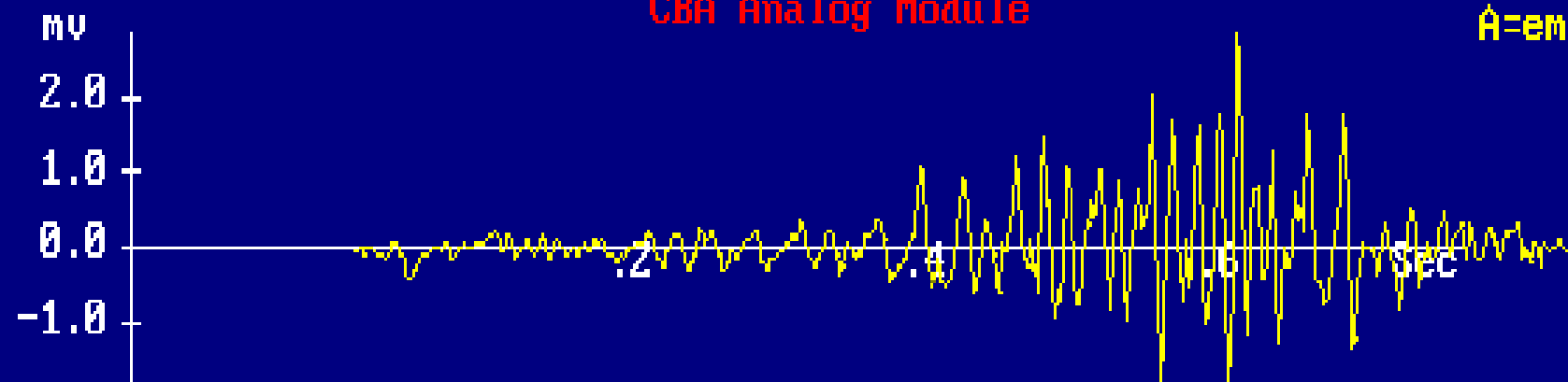
L=LLLP



X=Plate1-FX
Y=Plate1-FY
Z=Plate1-FZ

CBA Analog Module

A=emg



AnyKey To Advance

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

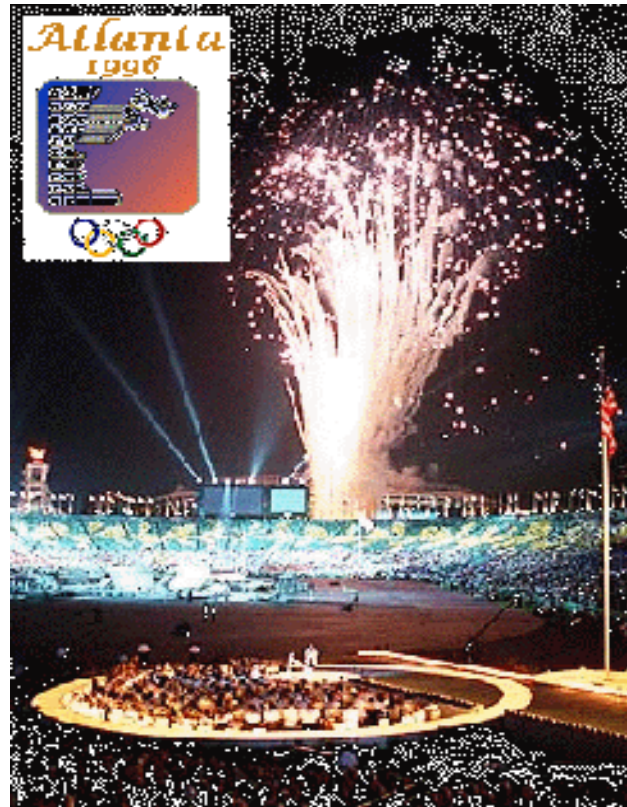


The purpose of the research conducted at the XXVI Olympiad in Atlanta was to expand the biomechanical applications and the interactive capabilities of the Internet to make sport performances rapidly available to everyone

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

- **Because of the strict accessibility to the field for security reasons, special locations had to be chosen and guarantee for setting video cameras.**
- **The main goal in the present study was to be able to load the data in to the Internet at the fastest time, so scientists, students and any interest group will be able to download the video and other data immediately from the Internet.**
- **The purpose of the present study was to analyze Track and Field performances in the Atlanta 1996 Olympic Games.**

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

Essentially, in Internet terms, the entire process consists of the following steps:

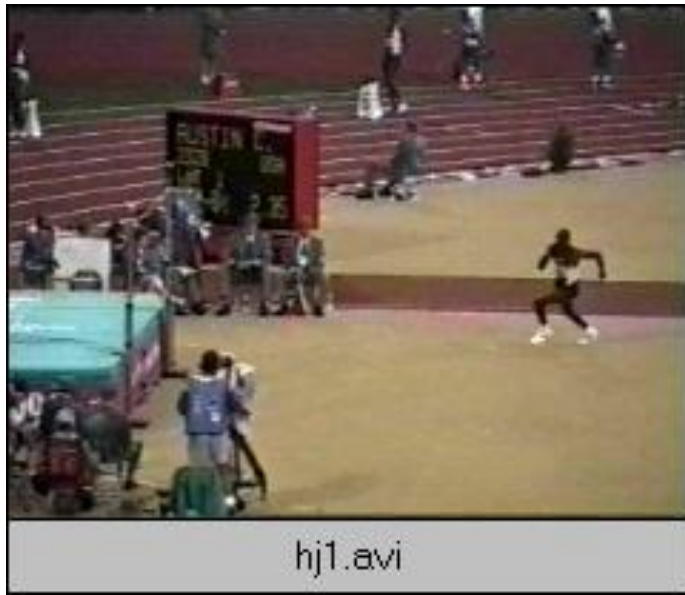
- **Analog video data is captured off-site and off-line through the use of a frame-by-frame advance VCR.**
- **Analog video data is converted off-site and off-line to digital video data in AVI format.**
- **Digital video data in AVI format is transmitted via FTP from a remote PC (browser) to a web server.**

- **The web server, converts the AVI frames into individual GIF files.**
- **The web server, through CGI, superimposes the x,y,z coordinates on the video images.**
- **The web server sends back the processed (digitized) image frames back to the remote PC (browser) with all pertinent mathematical and physical observations, analysis, and conclusions.**

**Utilizing the tools available in
Cyberspace, the Biomechanist,
The Coach and the Sport
Scientist can retrieve and display
data as well as documents from
virtually anywhere on the planet.
Studies can be conducted at
multiple locations and data
rapidly exchanged among these
sites.**

A BIOMECHANICAL STEP ONTO THE INTERNET

It is a window on the ever-expanding world of on-line information. The new communication links afforded by rapid satellite/computer exchanges bringing together hypertext multimedia and global networking. The Web is growing at an astounding rate and is changing the scientific world by making it possible for anyone to transmit and receive information around the world.



PROVIDE SIMULTANEOUS INTEGRATION OF:

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

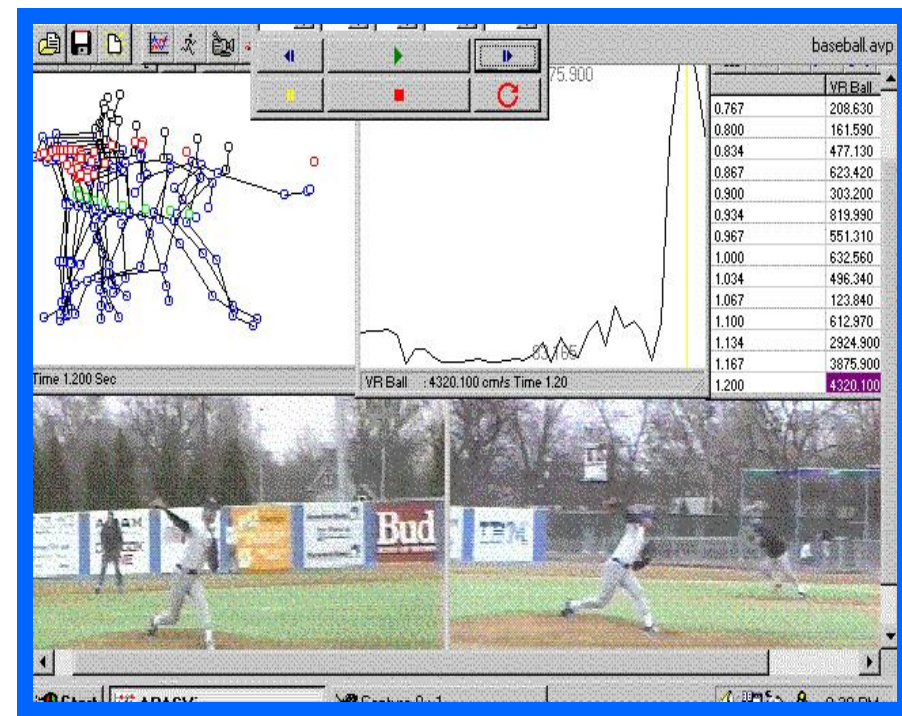
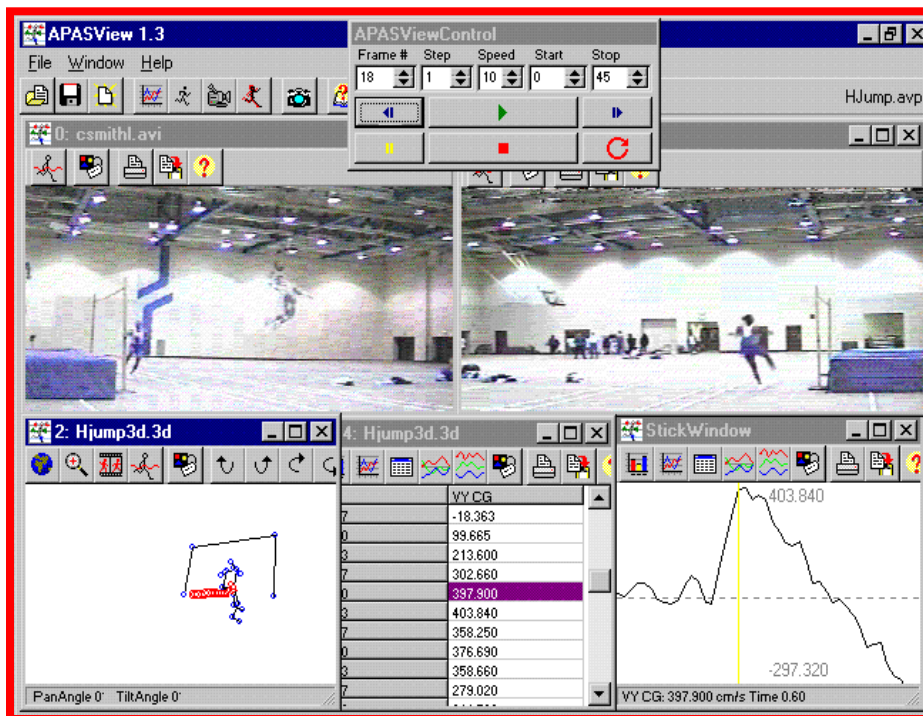
Applications

- **COACHING**
- **SPORT PERFORMANCE ANALYSIS**
- **OPTIMIZATION OF PERFORMANCE**

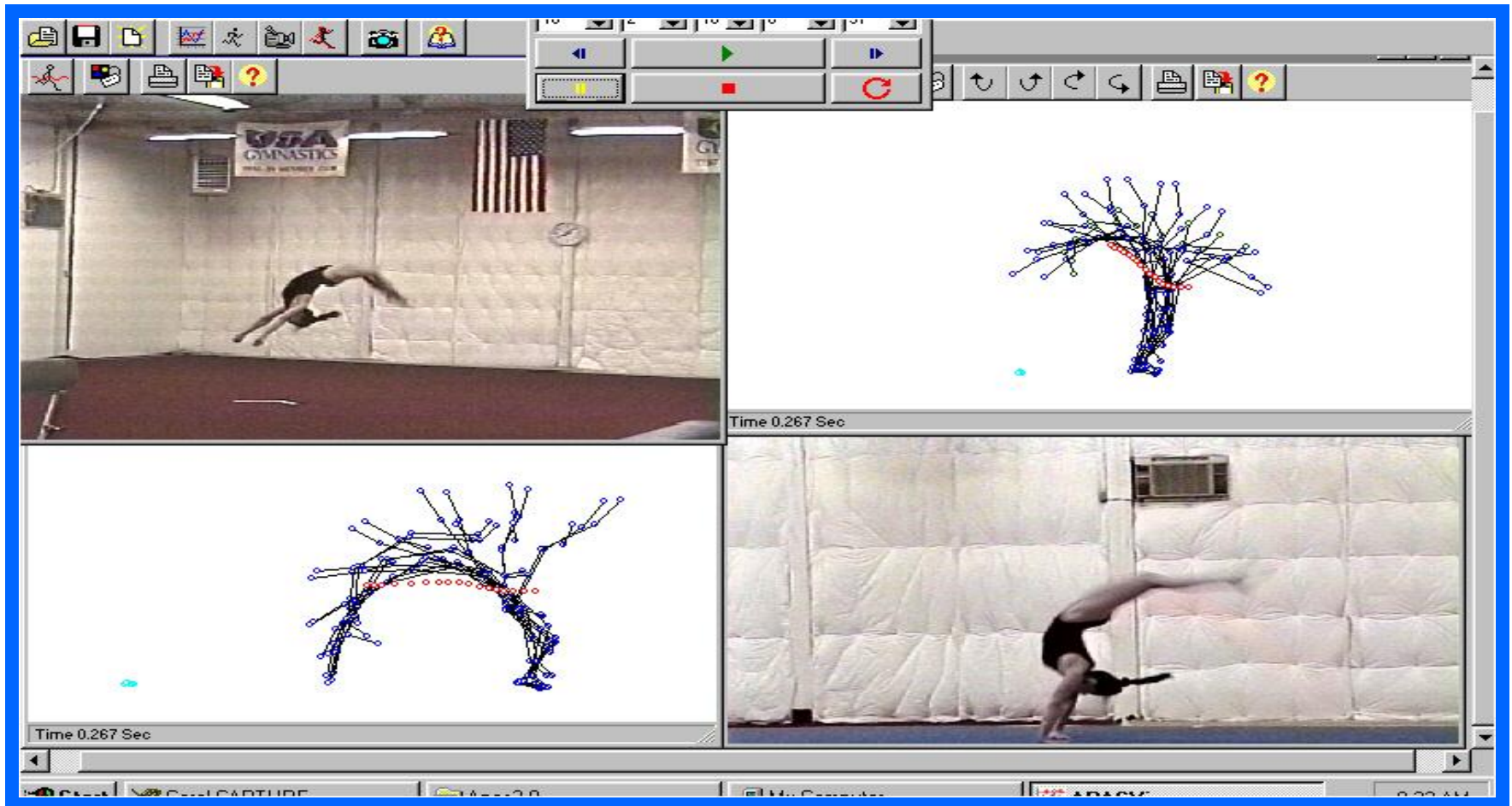
Program Integration and Synchronization



apaview.exe



Sports



The Cyber Coach



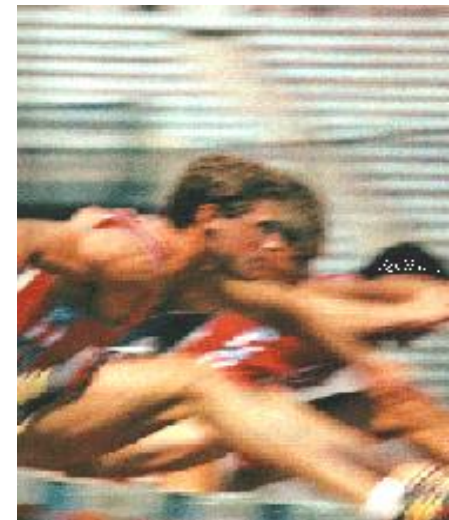
Hammer1.avi



Run1.avi



Hurdle1.avi





Pv1.avi

THANK YOU

