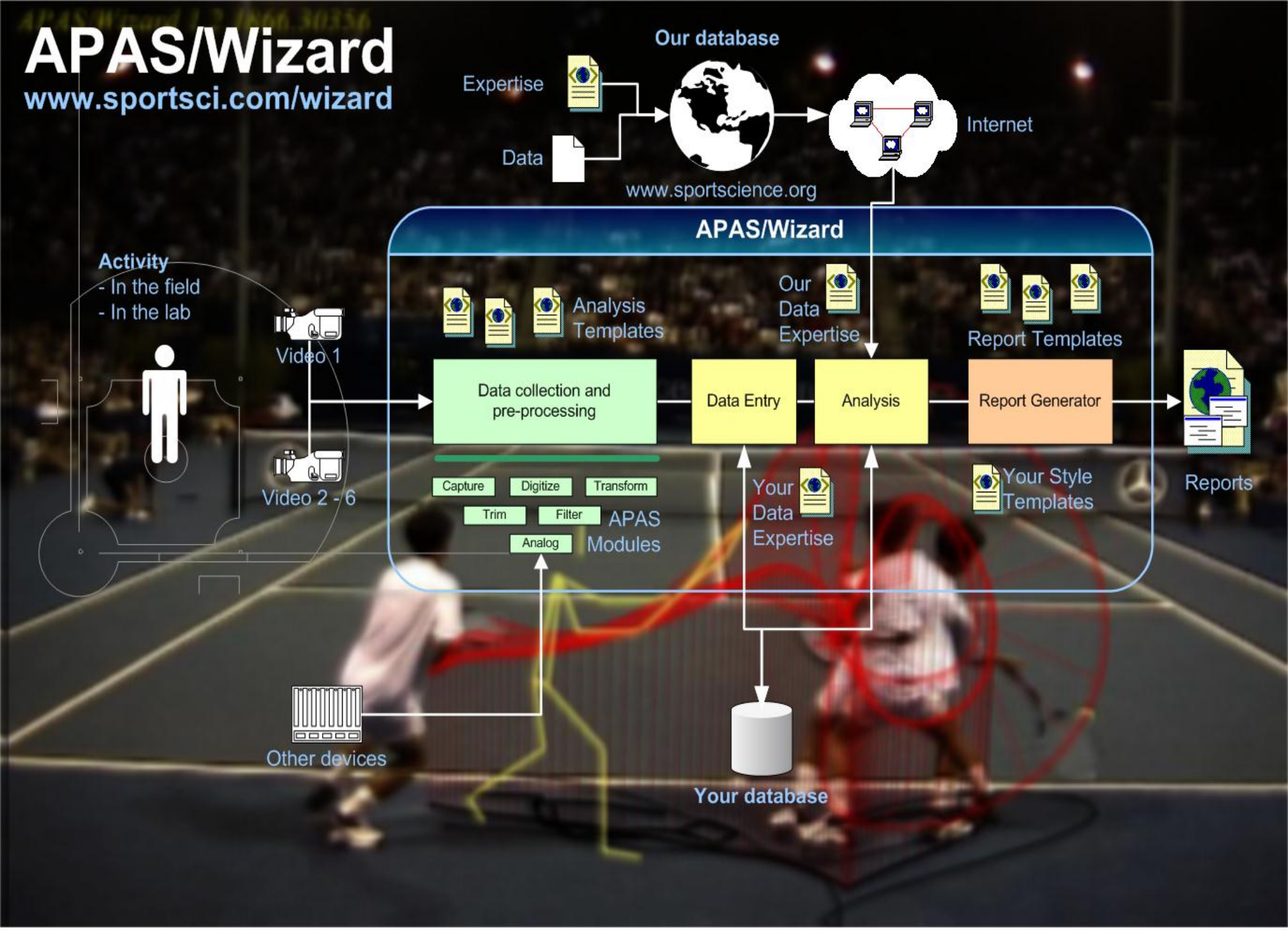
The Biomechanical Wizard

By Gideon Ariel, Ph.D.

Guangdong Provincial
Institute of Sport Science

February 22nd 2005


APAS/Wizard
www.sportsci.com/wizard
Our database
Expertise
Data
www.sportscience.org
Internet
APAS/Wizard
Activity
- In the field
- In the lab
Video 1
Video 2 - 6
Analysis Templates
Our Data Expertise
Report Templates
Data collection and pre-processing
Data Entry
Analysis
Report Generator
Reports
Capture
Digitize
Transform
Trim
Filter
Analog
APAS Modules
Your Data Expertise
Your Style Templates
Other devices
Your database

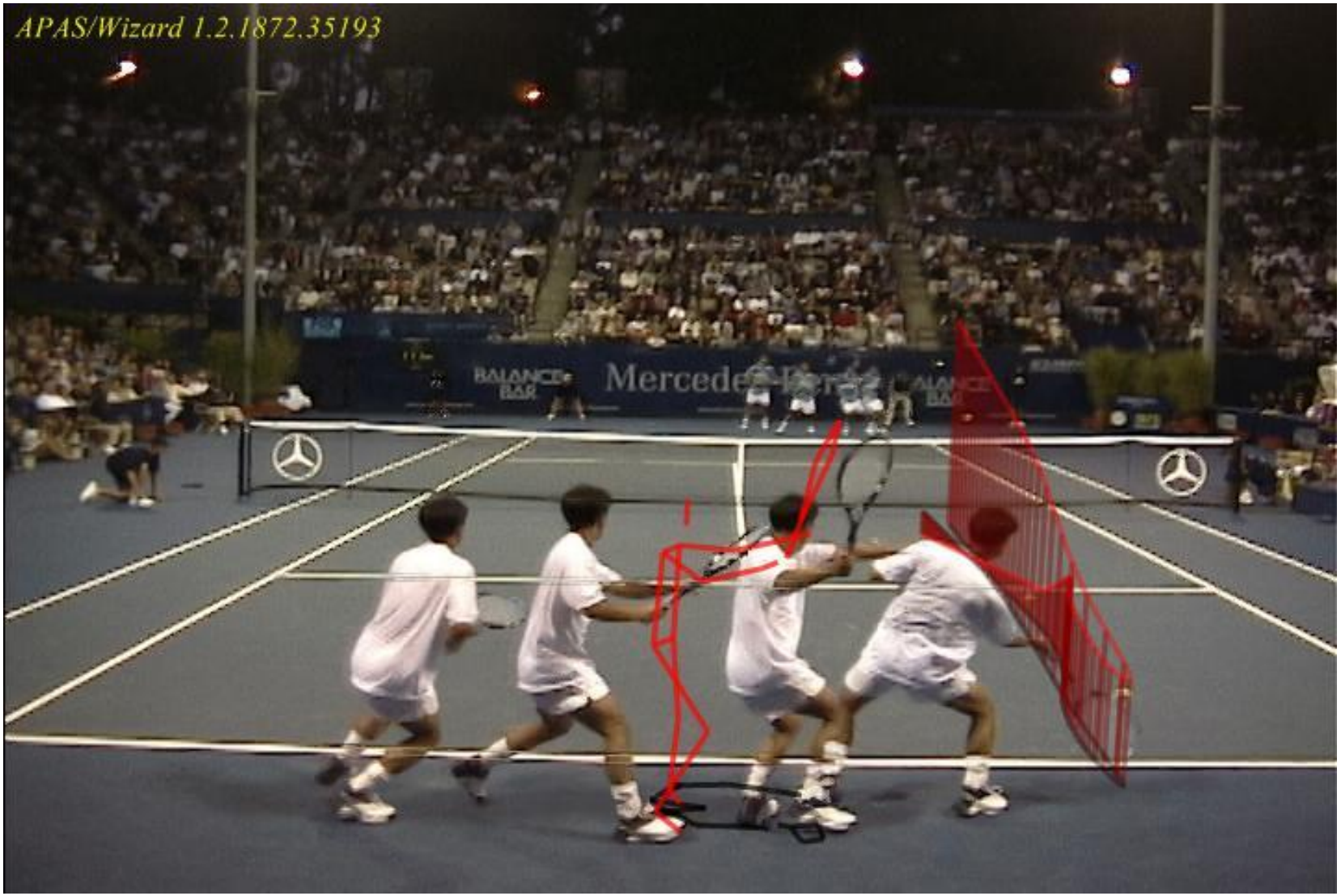

APAS/Wizard 1.2.1872.35193
BALANCE BAR
Mercedes
BALANCE BAR

Golf Strobing


APASWizard
BALANCE BAR
Mercedes-B
BALANCE BAR


APAS/Wizard 12.1874.21723
BALANCE BAR
Mercedes
BALANCE BAR

Kinematics and Strobing



APAS

Performance
Analysis
System

APAS is a **video-based 3D motion analysis** system which provides **objective biomechanical data** the professional may use **in any way** (s)he wants.

Use it for **biomechanics**.
Use it for **motion capture**.
Use it for **sports analysis**.
Use it for **gait analysis**.
Use it for **diagnosis** and **treatment outcome**.

ACES uniquely controls, records, evaluates and modifies **functional performance** with user defined parameters.

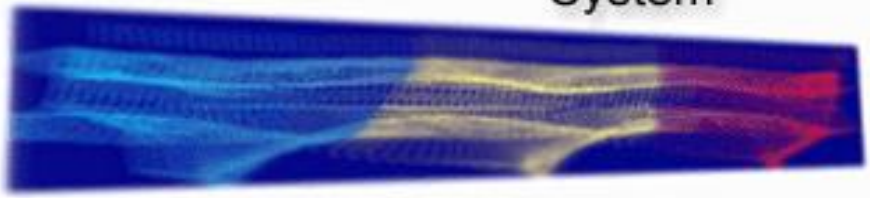
Use it to build **muscular strength** or **muscular endurance**.

Use it for **isometric**, **isotonic**, **isokinetic** or **muscle overload** training.

Perform any **variable resistance**, **variable velocity**, or **feedback controlled** exercise.

ACES

Computerized
Exercise
System



Brief History

- Mybridge, The Inventor of Recorded Motion 1894
- Mexico City Olympics 1968
- Montreal Olympics 1976
- Los Angeles Olympics 1984
- The USA Women Volleyball 1976-1984

More video clips at:

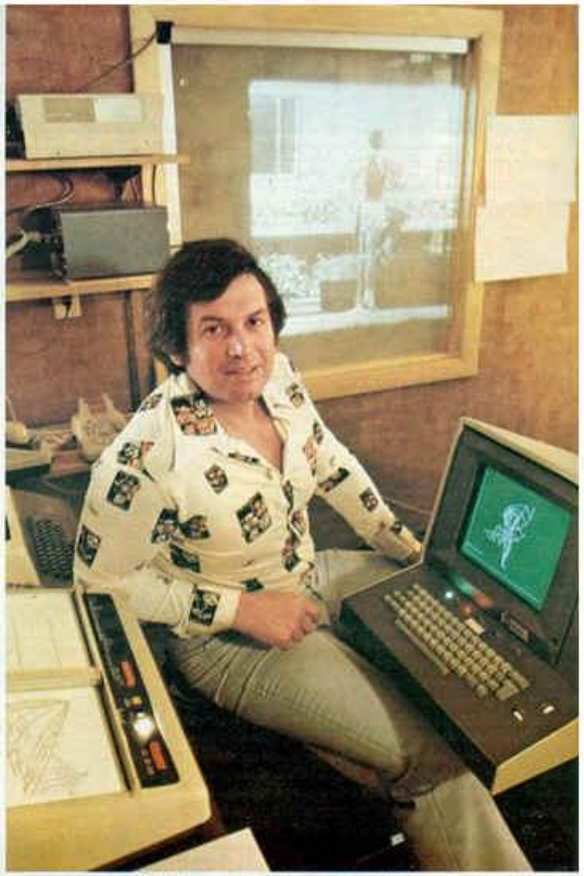
http://www.sportsci.com/media

Rear Projection Digitizing

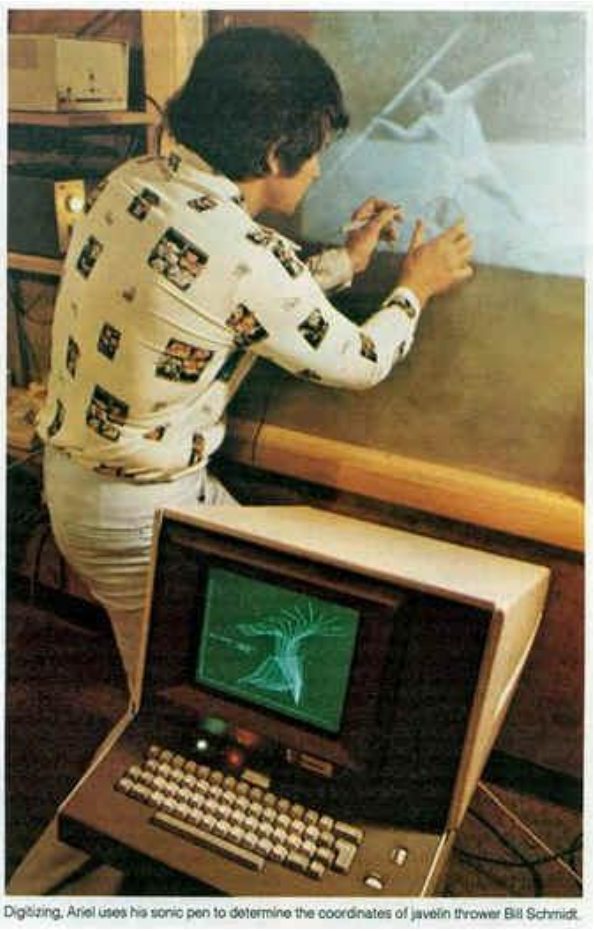
Sports Illustrated, August 1977

COMPUTER
continued

"Faith" is a fine invention
When Gentlemen can see—
But Microscopes are prudent
In an Emergency.
—EMILY DICKINSON



It took Ariel more than 10,000 hours to program his computer to analyze an athlete's motions.



Digitizing, Ariel uses his sonic pen to determine the coordinates of javelin thrower Bill Schmidt.

Working with Olympic Athletes

New Scientist, July 1980

New Scientist 24 July 1980

Can computers win gold medals?

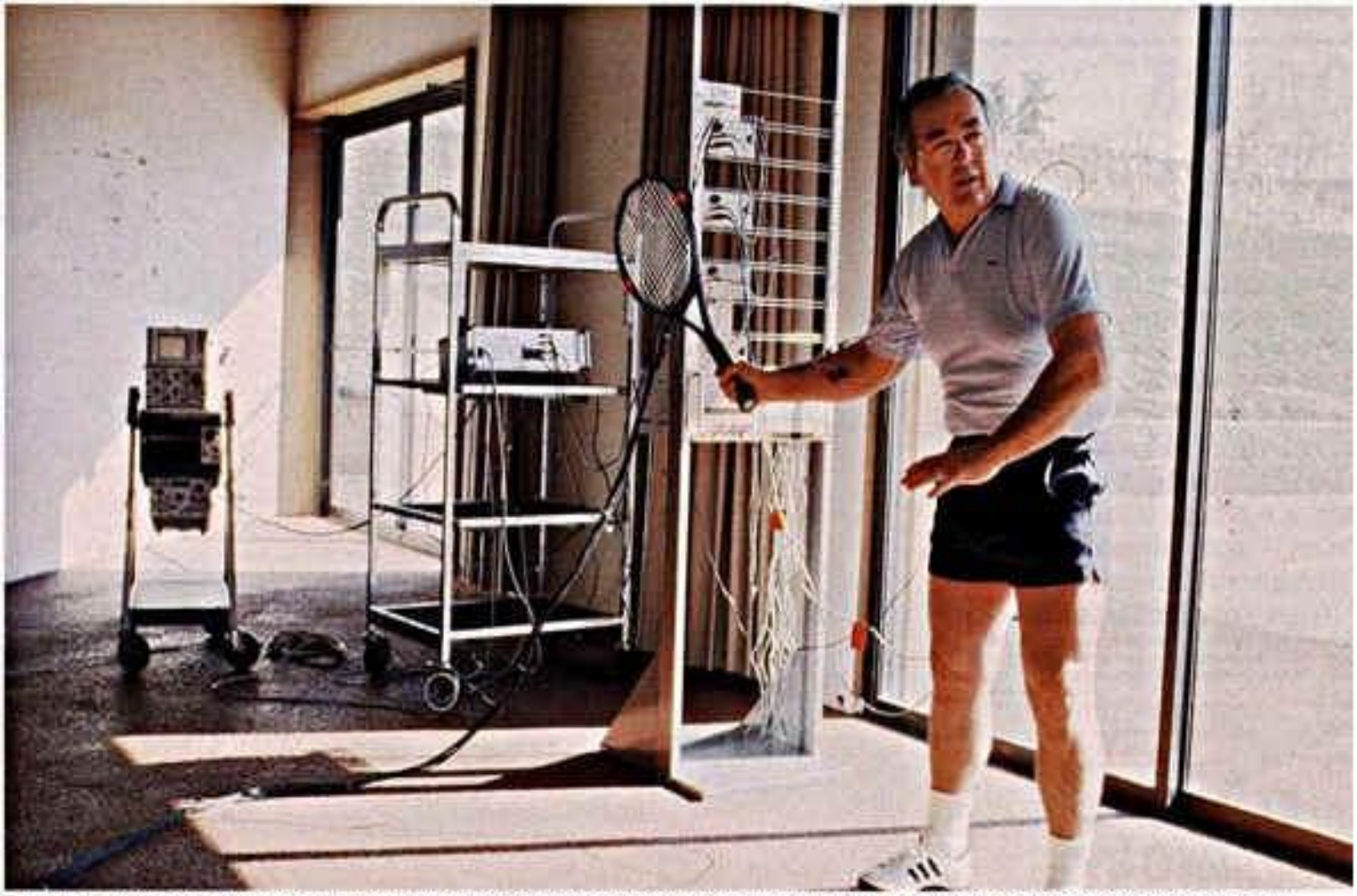
Computer technology allows us to analyse athletic performance in more detail than ever before. We can learn why some athletes win and how others might . . .

Gideon Ariel uses an electronic pen to trace a film frame of a shot putter; a computer simultaneously displays the image

Data General Corporation

USA Volleyball Olympic Team

Volleyball Monthly, April 1983



Tennis pro Vic Braden, hooked to a computer by electrodes, demonstrates how movement and muscle response can be tested to improve play.

"Human beings are creative, but we have terrible memories. Computers are ignorant, but their memories are infinite. You have to guide them step-by-step and channel your creativity through the computer software—which is the program created by human ingenuity."

Dr. Gideon Ariel
in SPORTS ILLUSTRATED

Coto Research's Sophisticated World of Computer Software

This is how the system works:

INDIRECT ANALYSIS

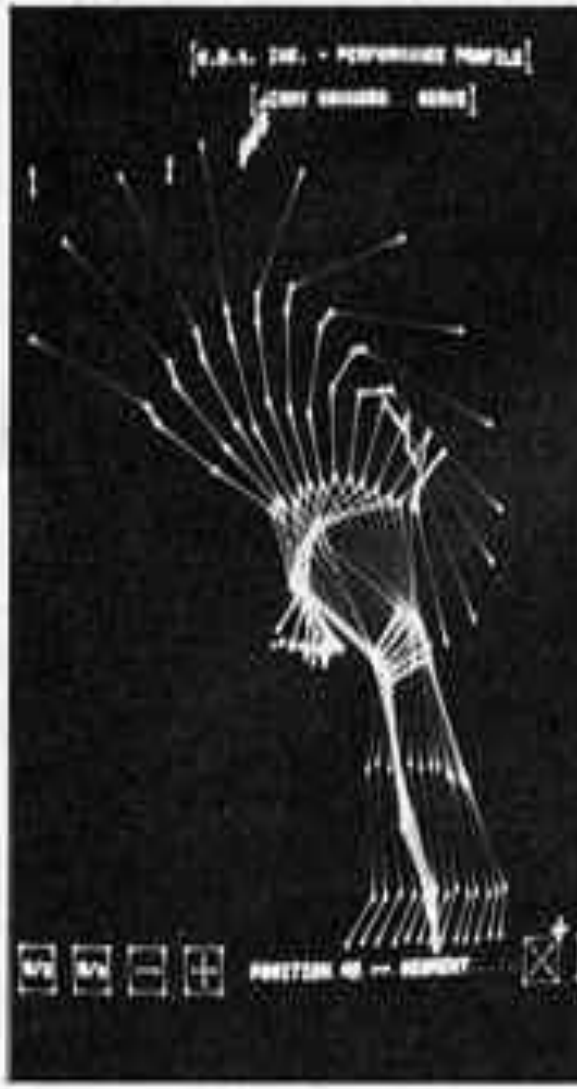
HIGH SPEED CINEMATOGRAPHY

High speed cameras are used to take motion pictures from multi-angled views to provide accurate positional data. Above, Flo Hyman of the U.S. Womens Olympic Volleyball Team.

DIGITIZING

After high speed movies are taken, the image is projected, frame by frame, onto a sophisticated digitizer which inputs into the computer memory the location of each of the body's joint centers. This procedure is repeated for each camera angle. Dr. M. Ann Penny demonstrates this digitizing process.

USAIR, October 1980

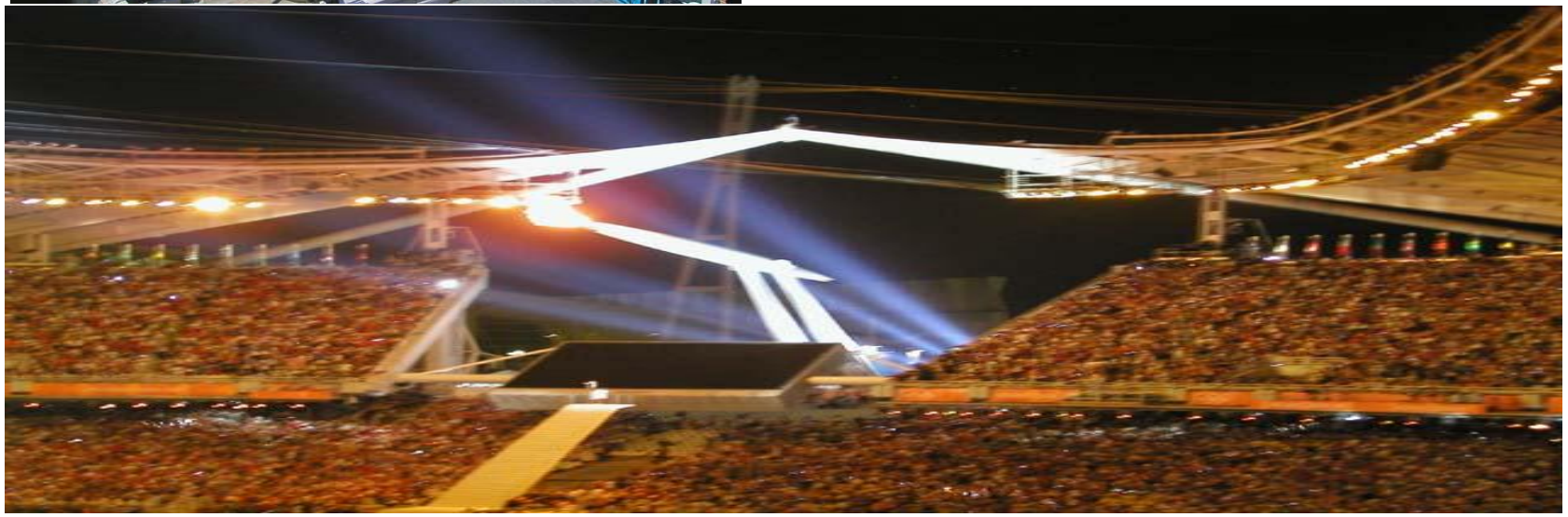


To analyze the body's efficiency, Ariel runs a film of the athlete through a computer, freezing each frame and measuring critical angles and lengths with a magnetic pen (left). The computer then creates a schematic printout (right)—in this case, of Jimmy Connors as he serves.

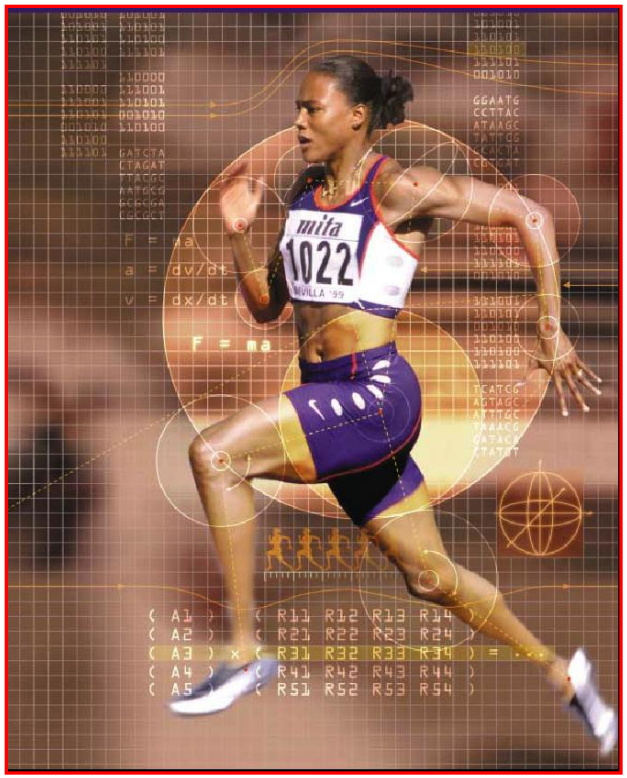
With Professor Zhang at our laboratory in Coto De Caza 2001

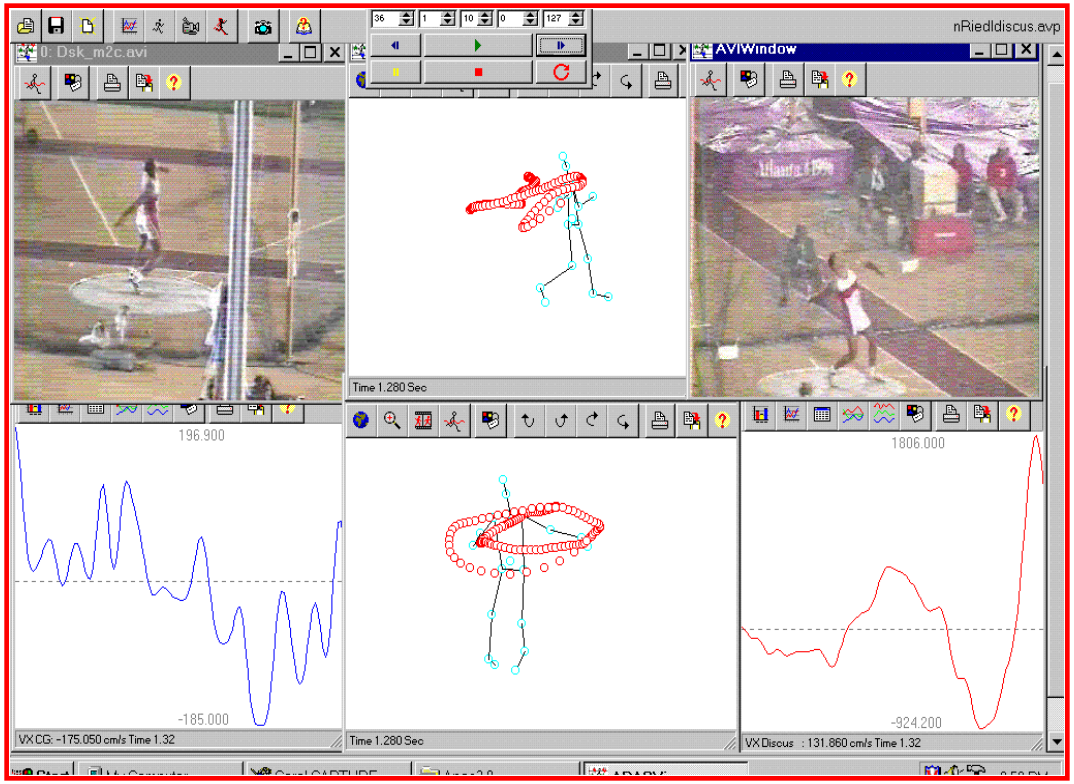
The Biomechanics Conference in Guangzhou - 2003

Athens Olympics 2004



Optimizing Athletic Performance Through High-Technology Utilizing the APAS Wizard System

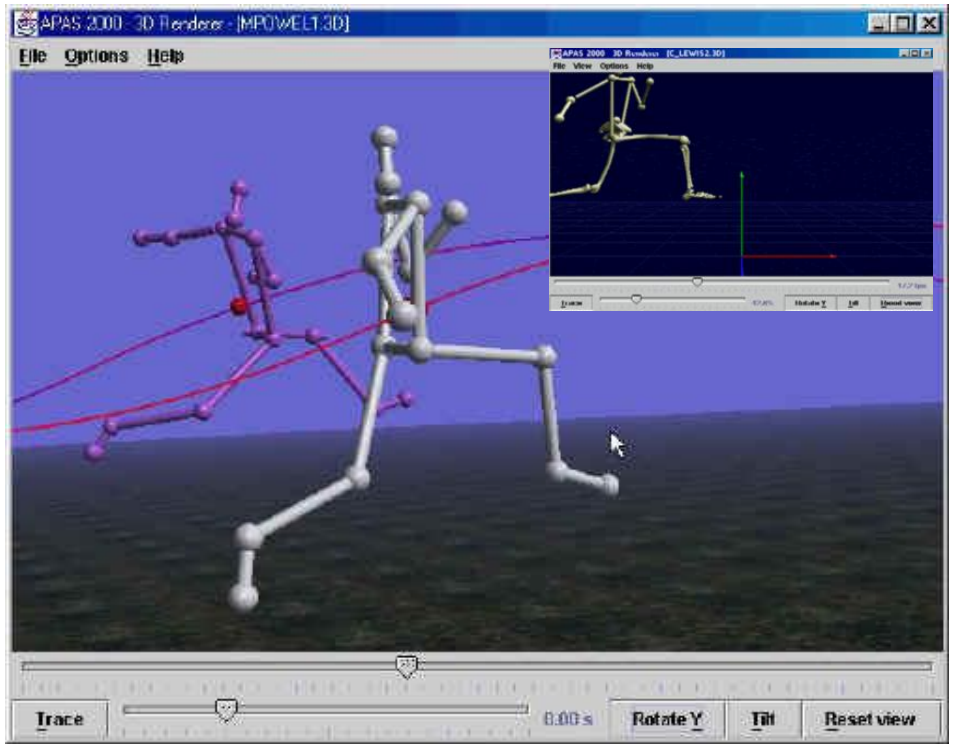




By Gideon Ariel, Ph.D.
Athens Olympics, 2004

Data Collection at the Athens Olympics-2004

MOVEMENT ANALYSIS CAN BE APPLIED TO:

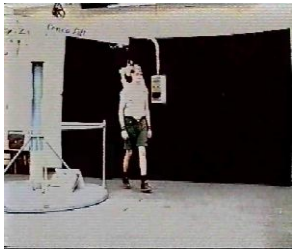


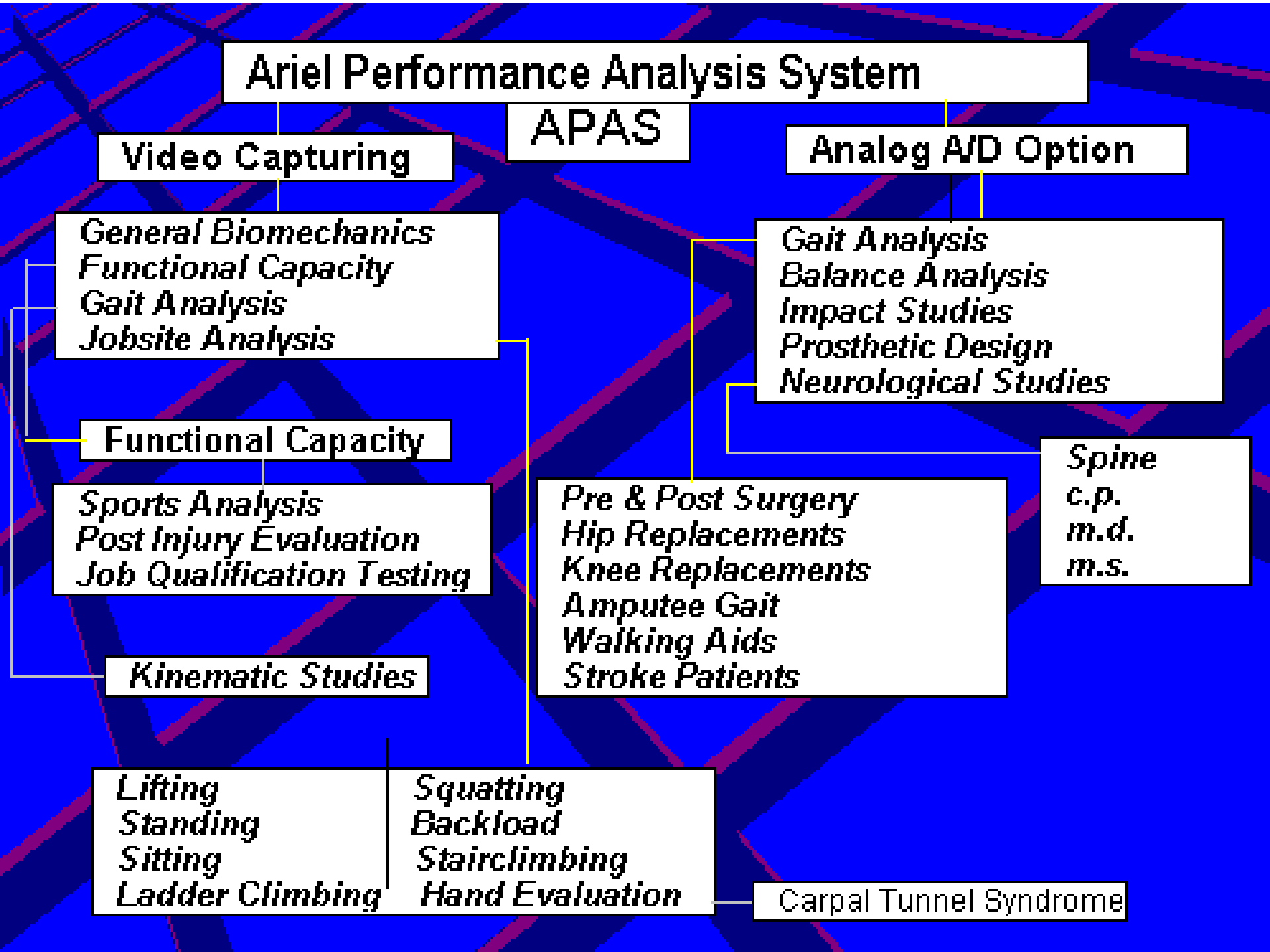
Athletics

Industry

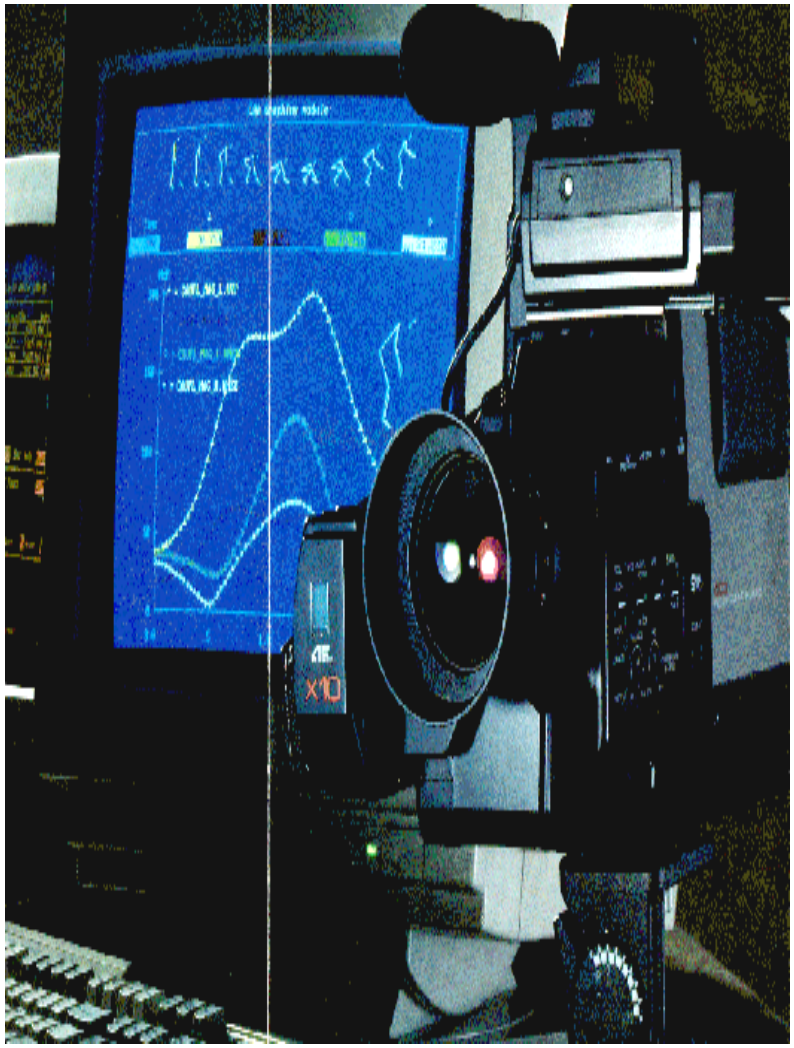
Medicine

Space

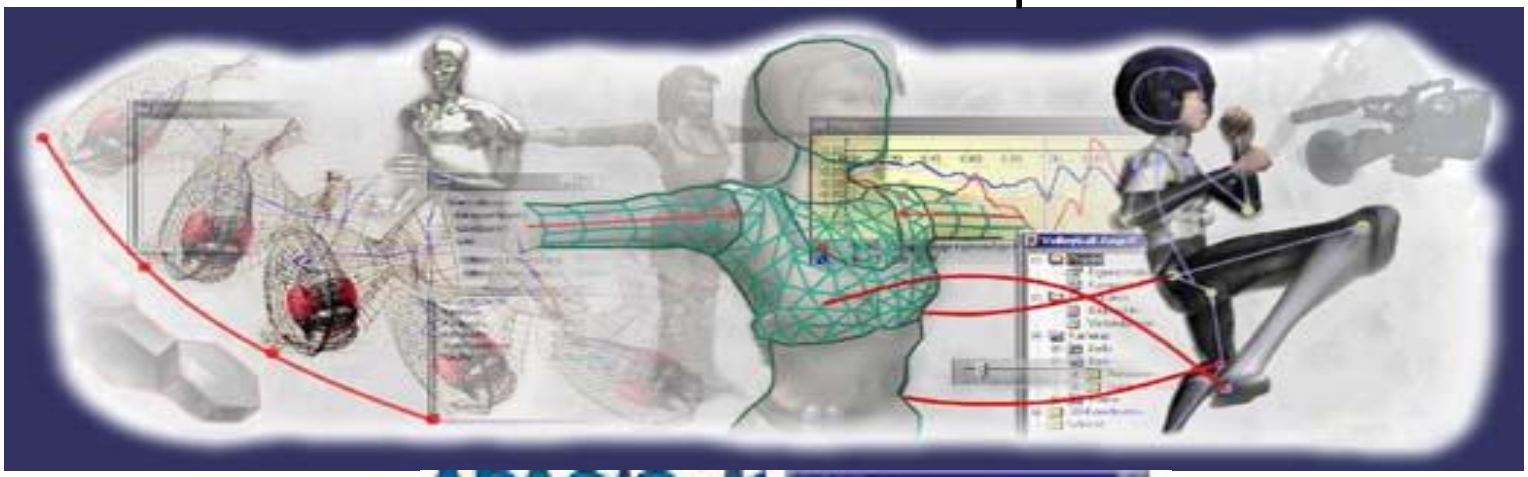



Ariel Performance Analysis System
APAS
Video Capturing
Analog A/D Option
General Biomechanics
Functional Capacity
Gait Analysis
Jobsite Analysis
Gait Analysis
Balance Analysis
Impact Studies
Prosthetic Design
Neurological Studies
Functional Capacity
Spine
c.p.
m.d.
m.s.
Sports Analysis
Post Injury Evaluation
Job Qualification Testing
Pre & Post Surgery
Hip Replacements
Knee Replacements
Amputee Gait
Walking Aids
Stroke Patients
Kinematic Studies
Lifting
Standing
Sitting
Ladder Climbing
Squatting
Backload
Stairclimbing
Hand Evaluation
Carpal Tunnel Syndrome

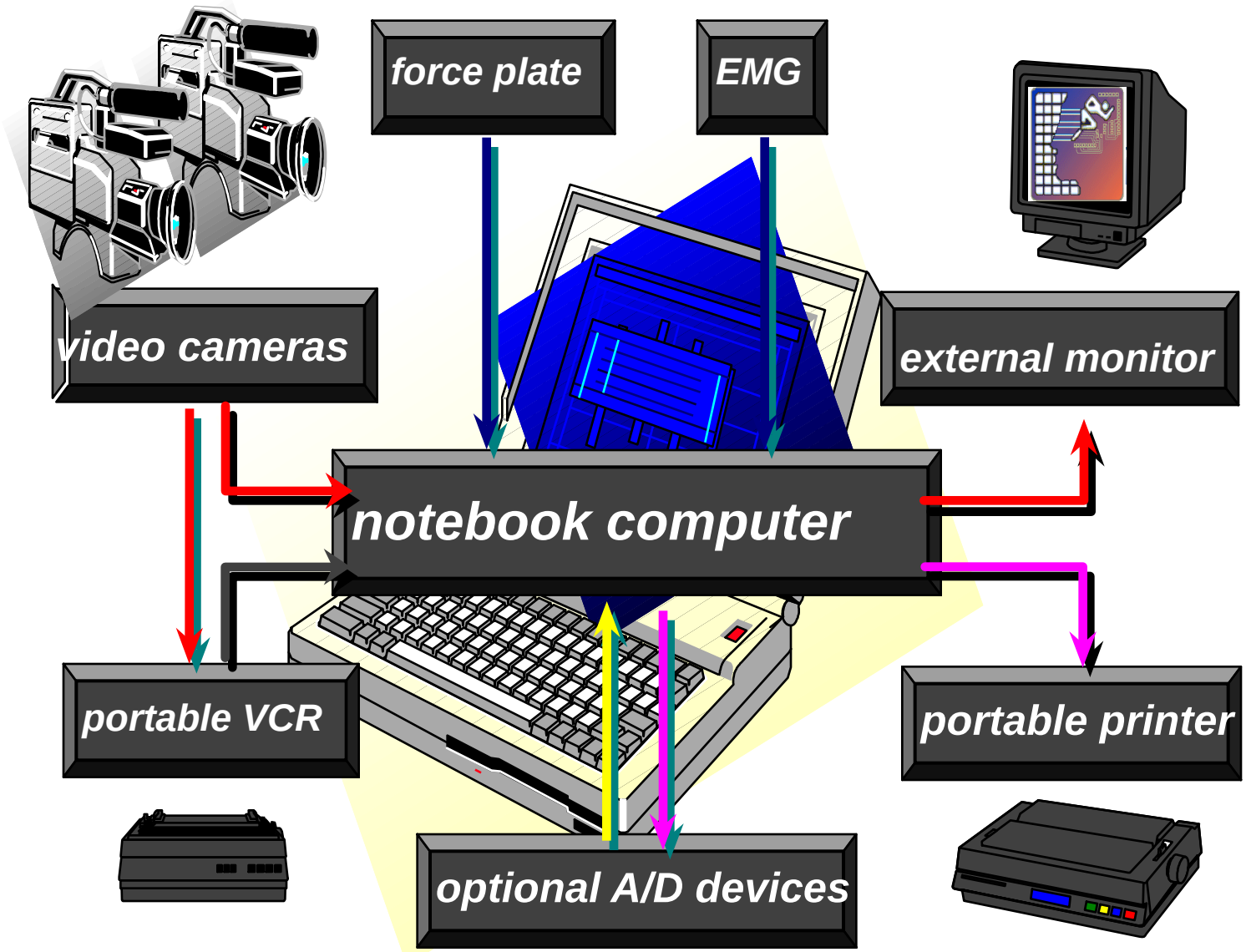
ALL APPLICATIONS UTILIZED SIMILAR QUANTIFICATION TECHNIQUES



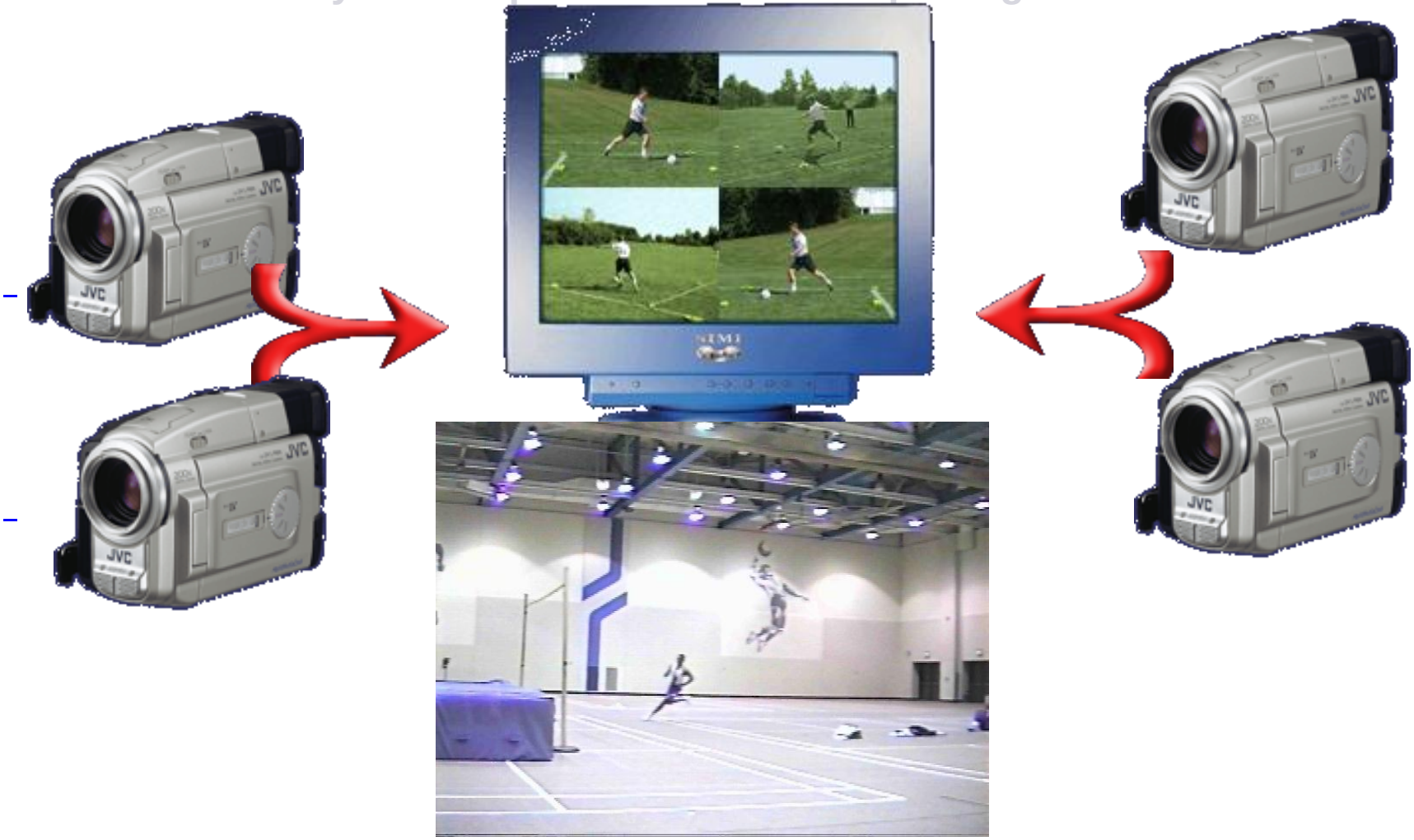
Captures Movement in Three-Dimensional Space



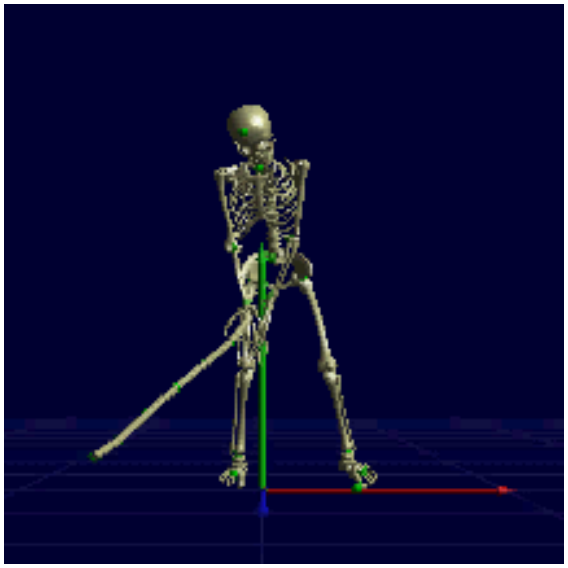
Basic Components of Motion Analysis System



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.



HIGH TECHNOLOGY



- 3D Kinematic Computer Analysis of Motion
- Kinetic [force] Ground Reaction Forces / Balance
- Computerized Strength Analysis Equipment
- Dynamic EMG [electromyography]

The Spectrum of Athletic Performances

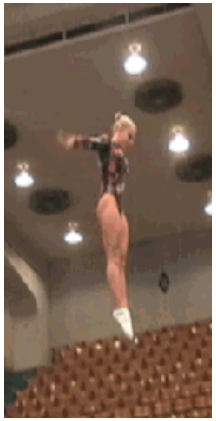
- Explosive Events
  - Throwing
  - Sprinting
  - Jumping

- Endurance Events
  - Long Distance Run
  - Swimming
  - Cycling

- Accuracy Events
  - Golf
  - Archery

- Team Sports
  - Soccer
  - Basketball
  - Hockey

- Esthetic Events
  - Figure Skating
  - Gymnastics
  - Diving

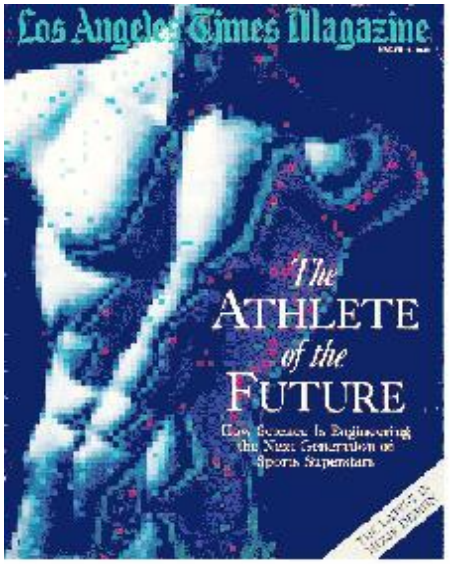


- Multi Events
  - Decathlon
  - Pentathlon

Analysis of Performance Require:

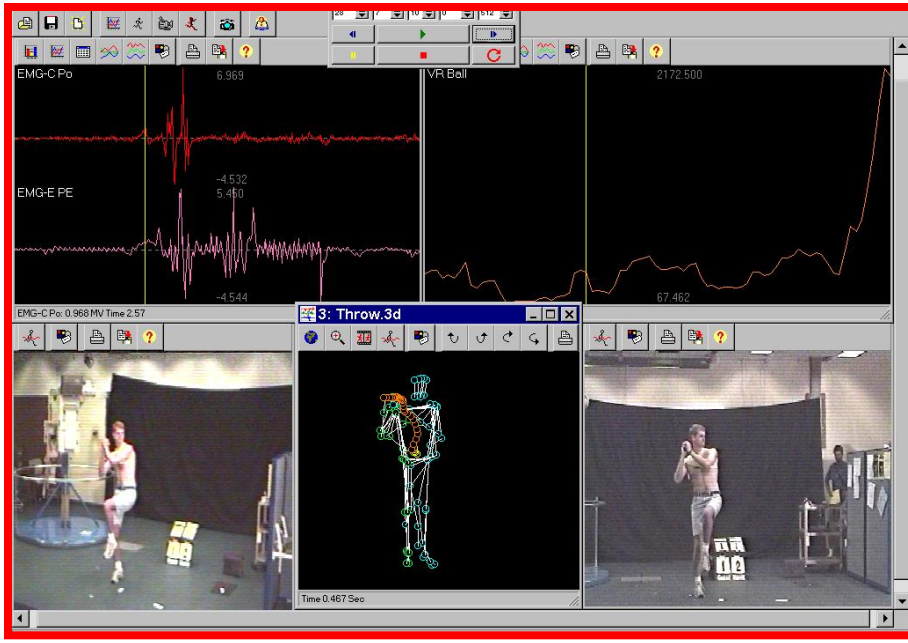
Video Recording
Digitizing the Data
- **Manual**
- **Automatic**

Transformation of the Data
- **2D - Two Dimensional**
- **3D - Three Dimensional**



Hardware

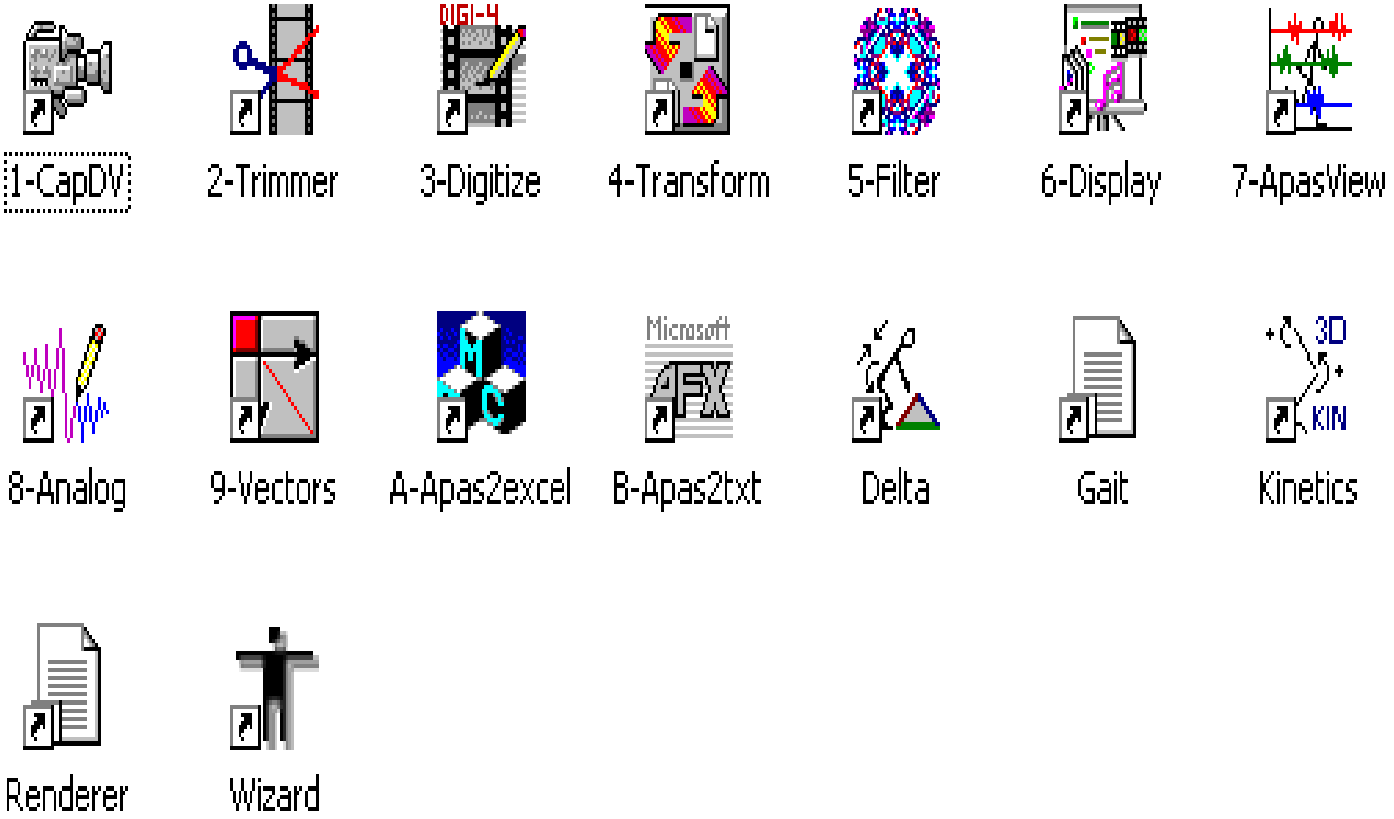
- Main Computer System
- Workstations
- High Speed Camera
- Capture Card
- Network
  - Intranet
  - Internet

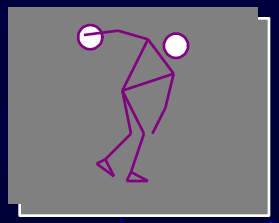


The APAS System

DLT

Filter

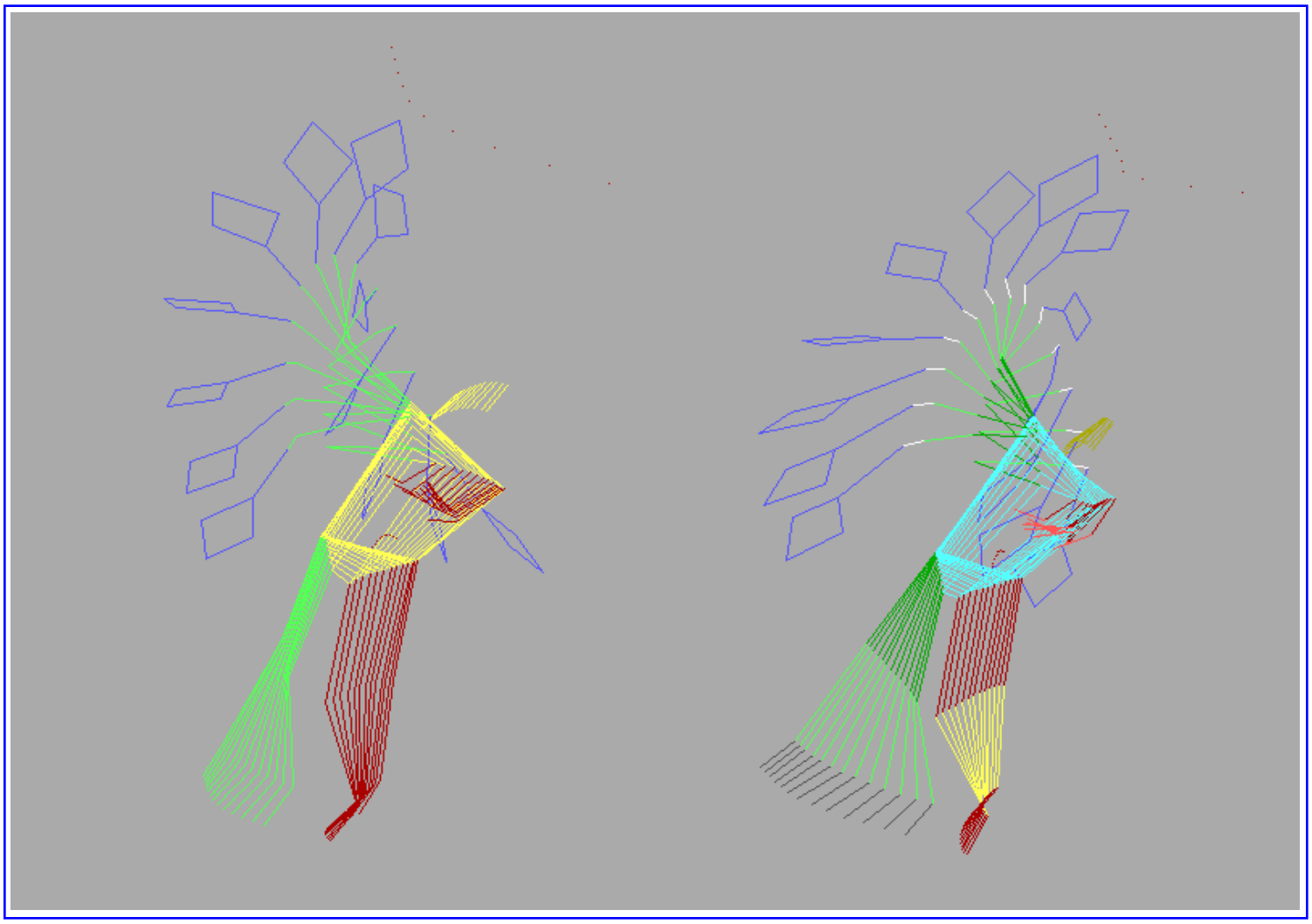


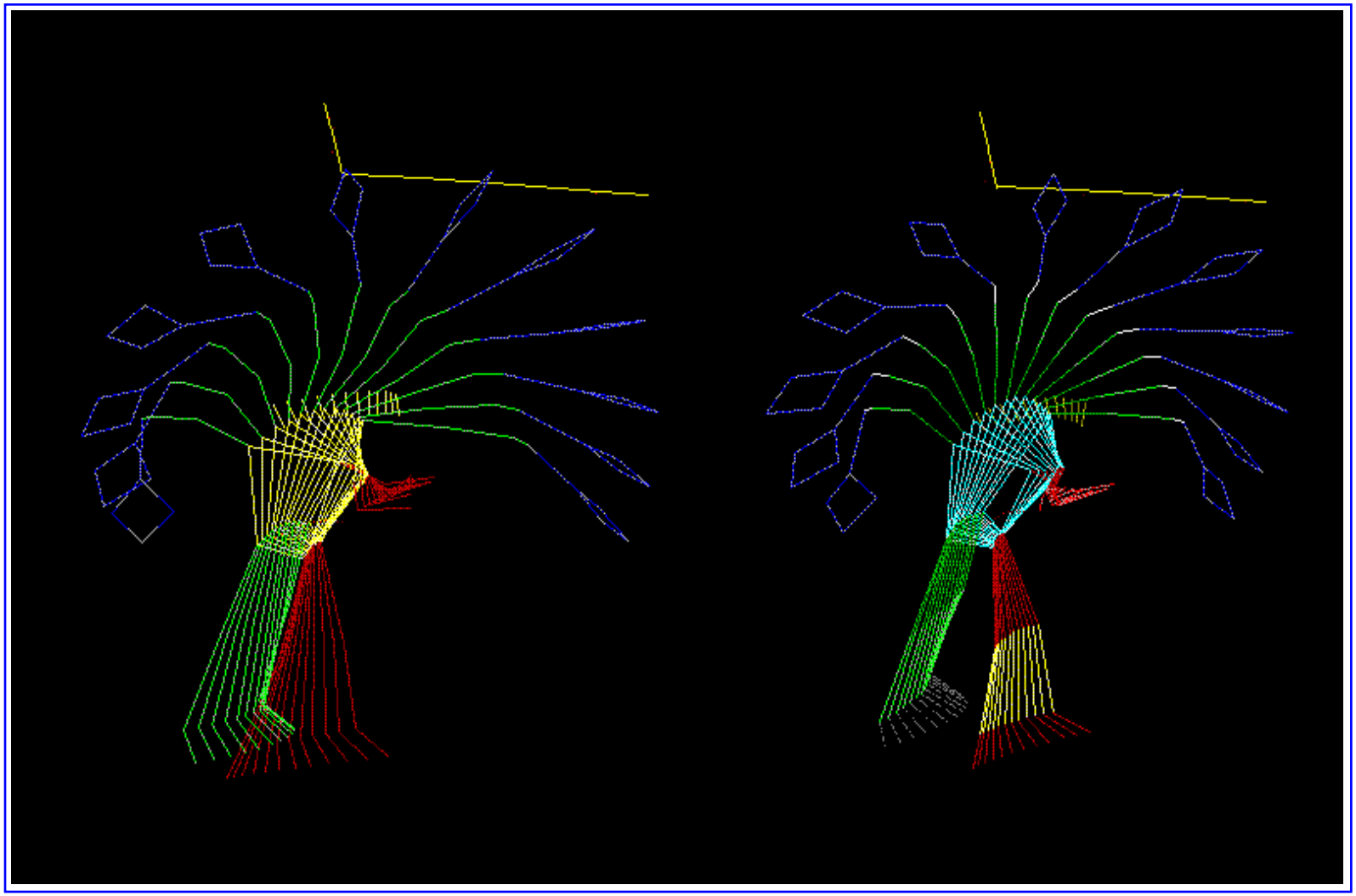


INTERNATIONAL CENTER FOR BIOMECHANICAL RESEARCH

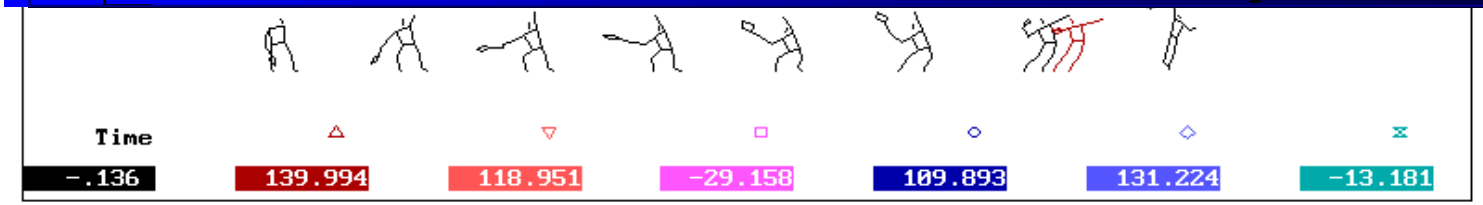
BIOMECHANICAL SIMILARITIES AND DIFFERENCES OF A.AGASSI'S FIRST AND SECOND SERVES

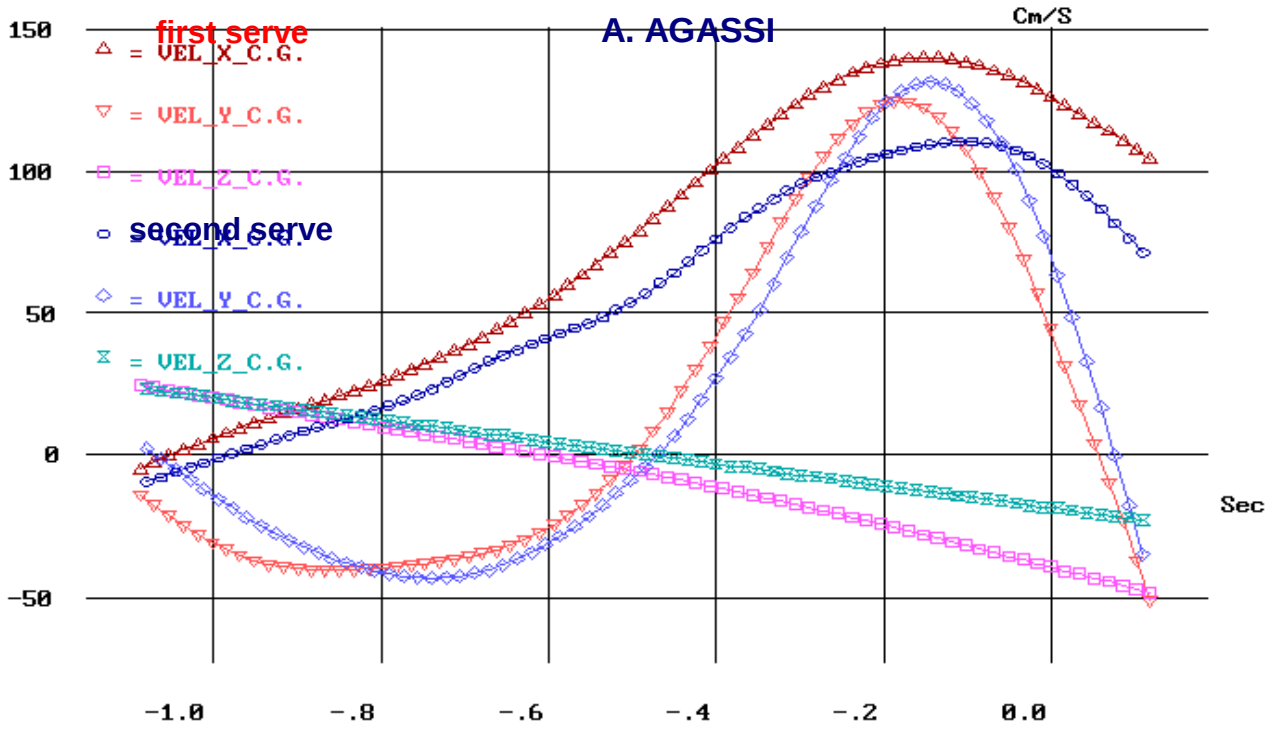
A. Vorobiev, G. Ariel, D. Dent



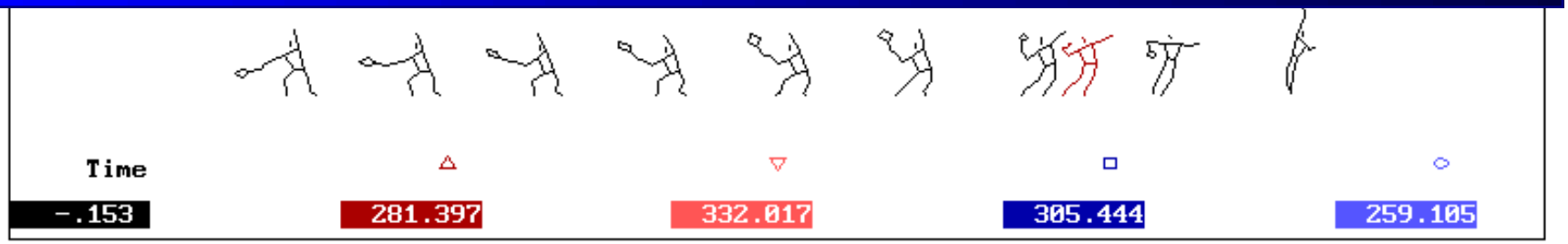


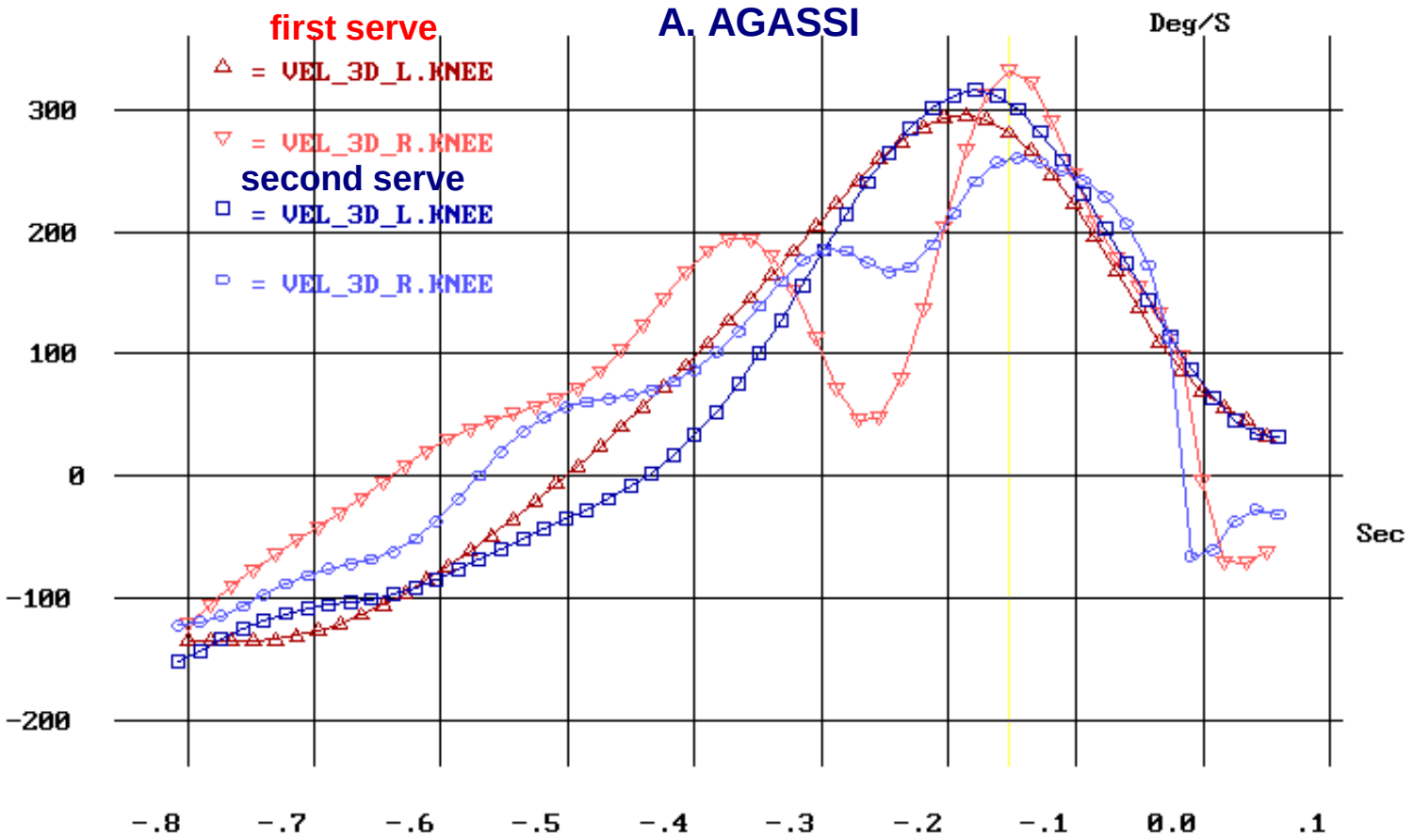
velocities of the Center of Gravity





velocities of knee extension





velocities of hip rotation

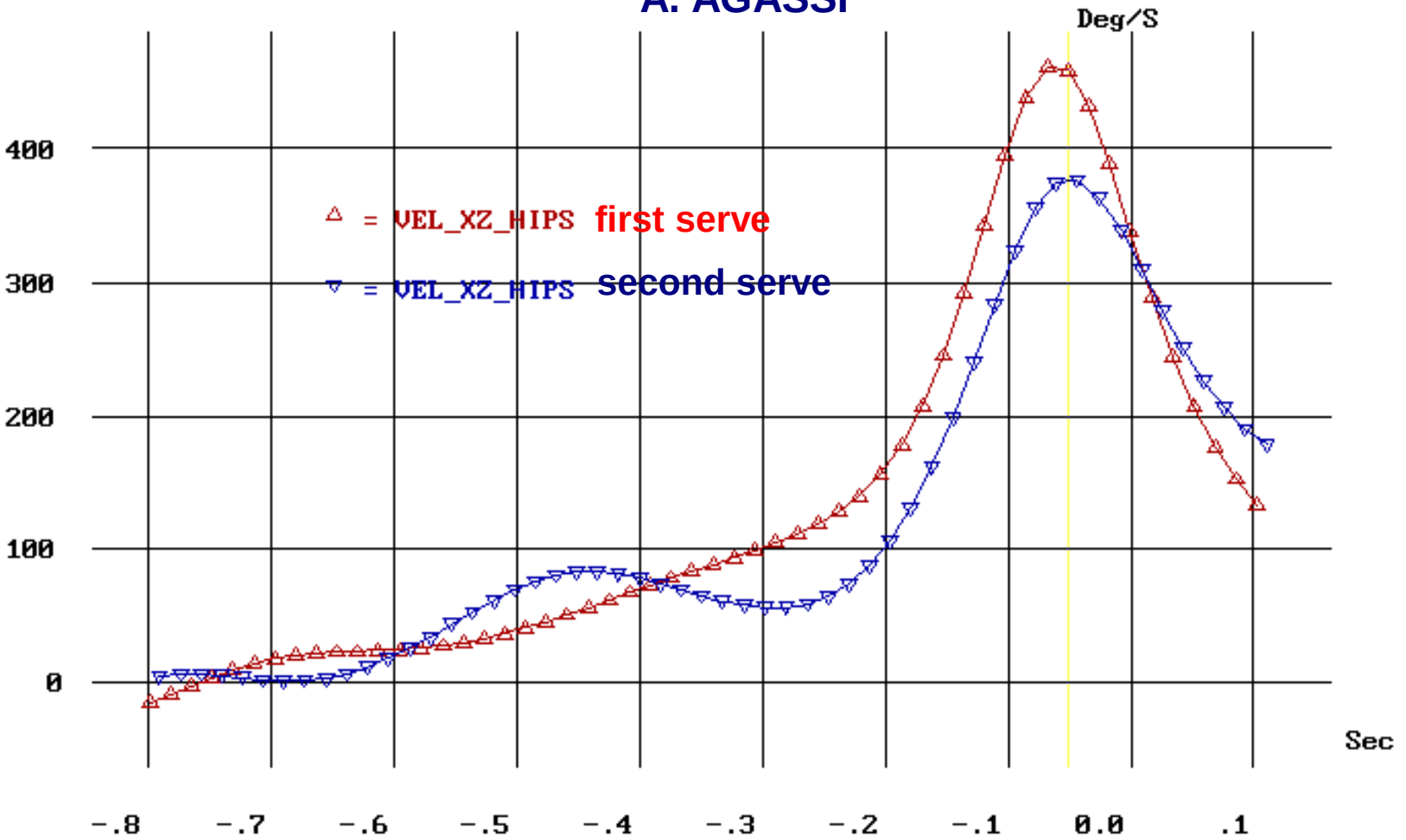
Time

△ -.051

▽ 459.309

375.179

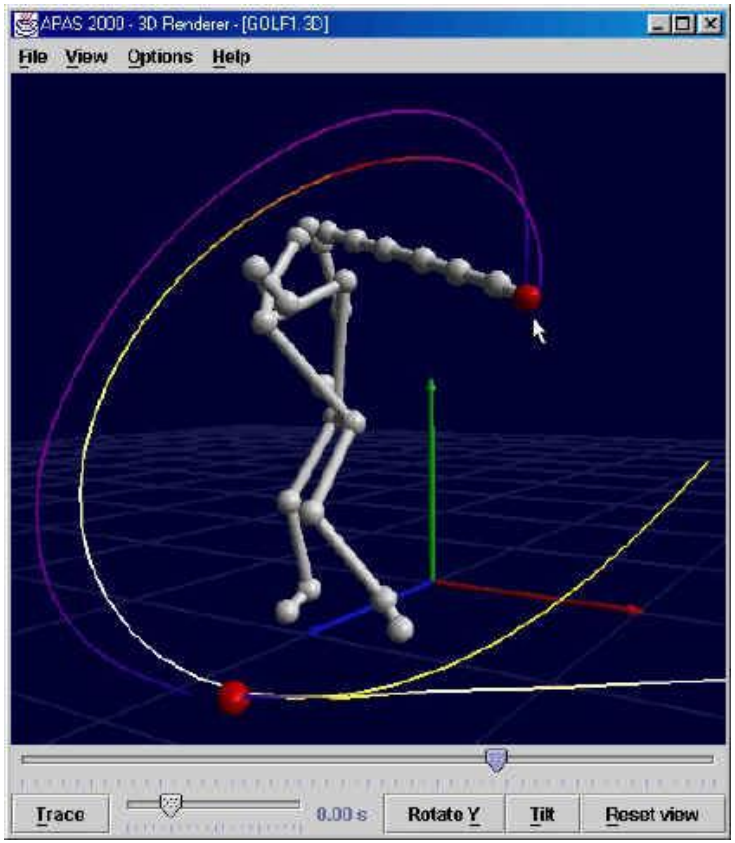
A. AGASSI

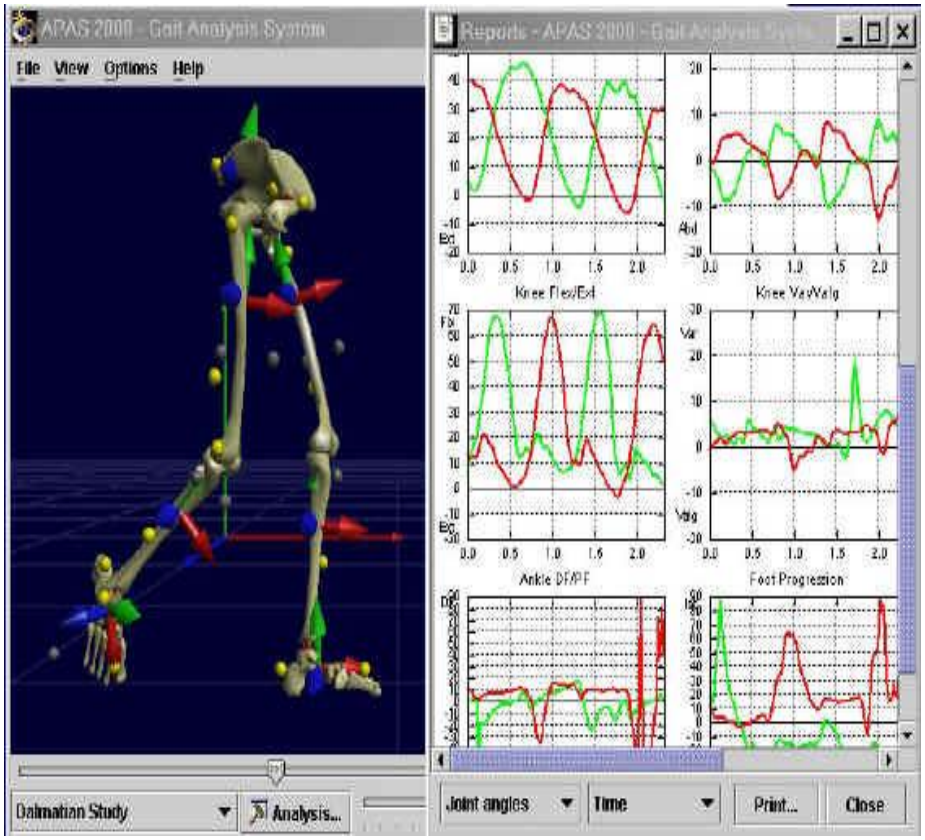


comparison of A. Agassi's first and second serves

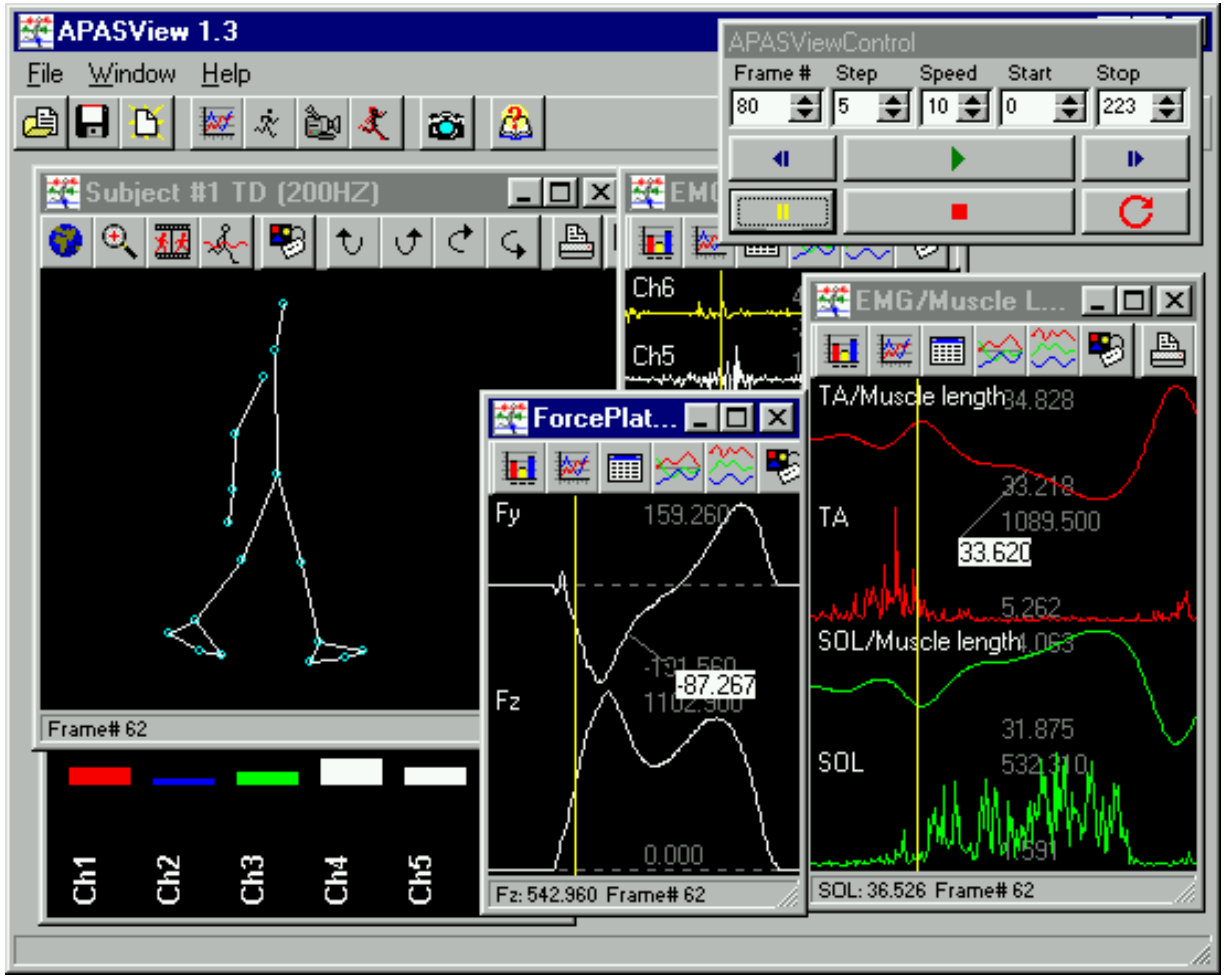
Kinematic Parameters	First Serve	Second Serve
Ball Speed at the Moment of Impact [n	45.8+-2.2	37.9+-2.4
Directional Angle [degrees]	17+-4	10+-5
Ball Position at the impact relative to the [m]		
Forward	.13+-.02	0+-.03
Left Lateral	.12+-.04	.36+-.04
CG Maximal Speed [m/s]	1.89+-.1	1.71+-.09

Software Integration

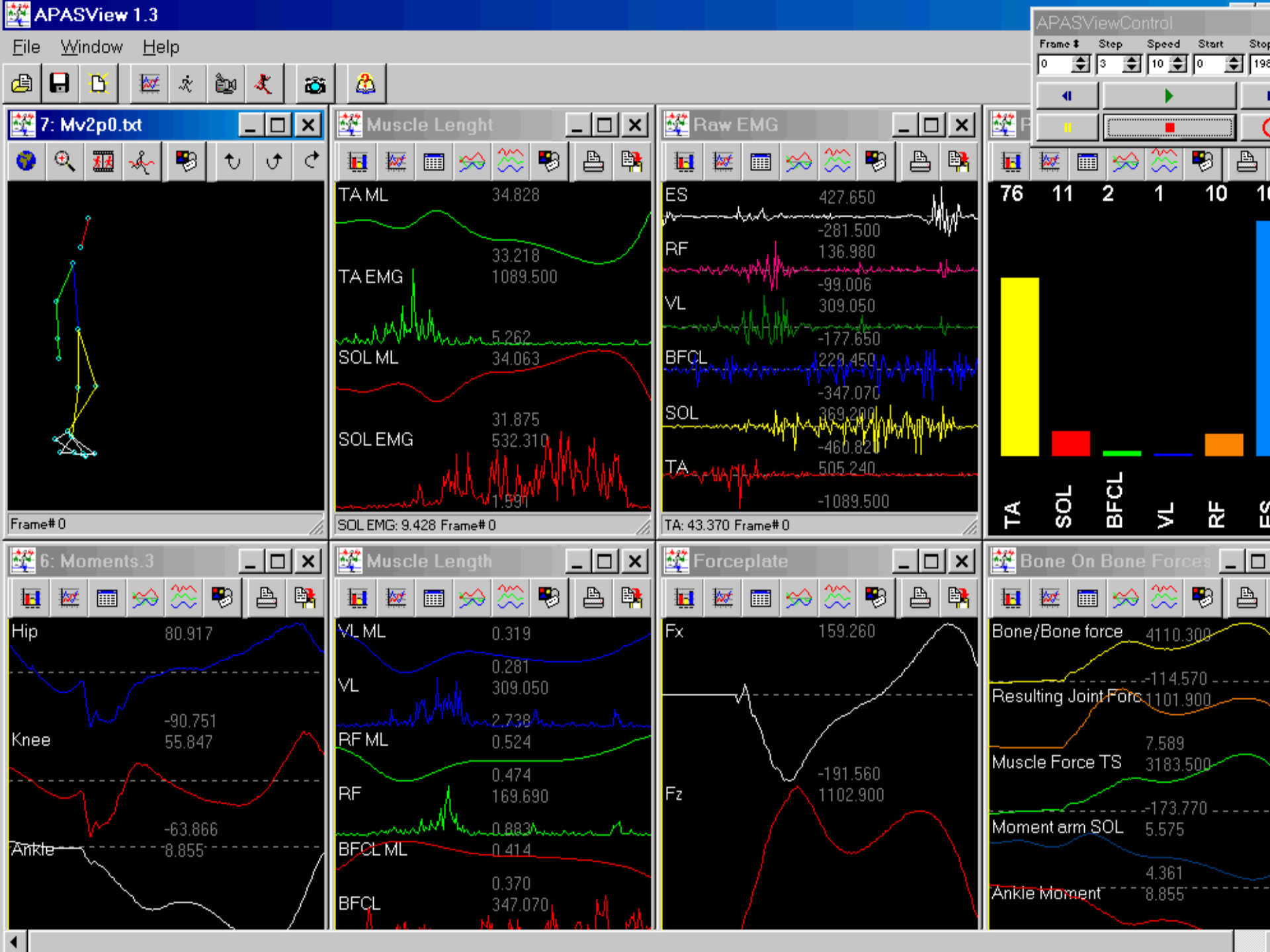


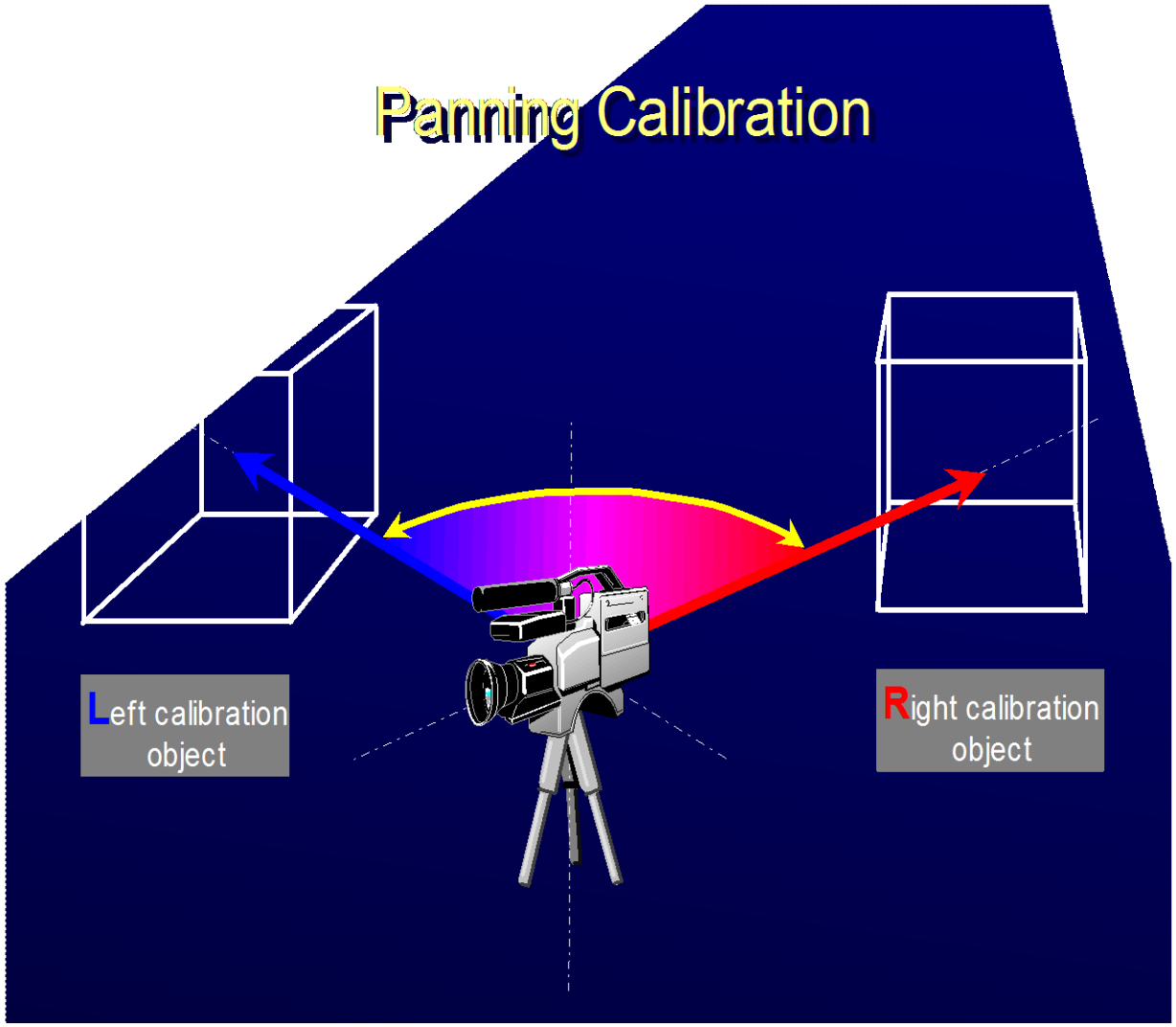


Display and Analysis

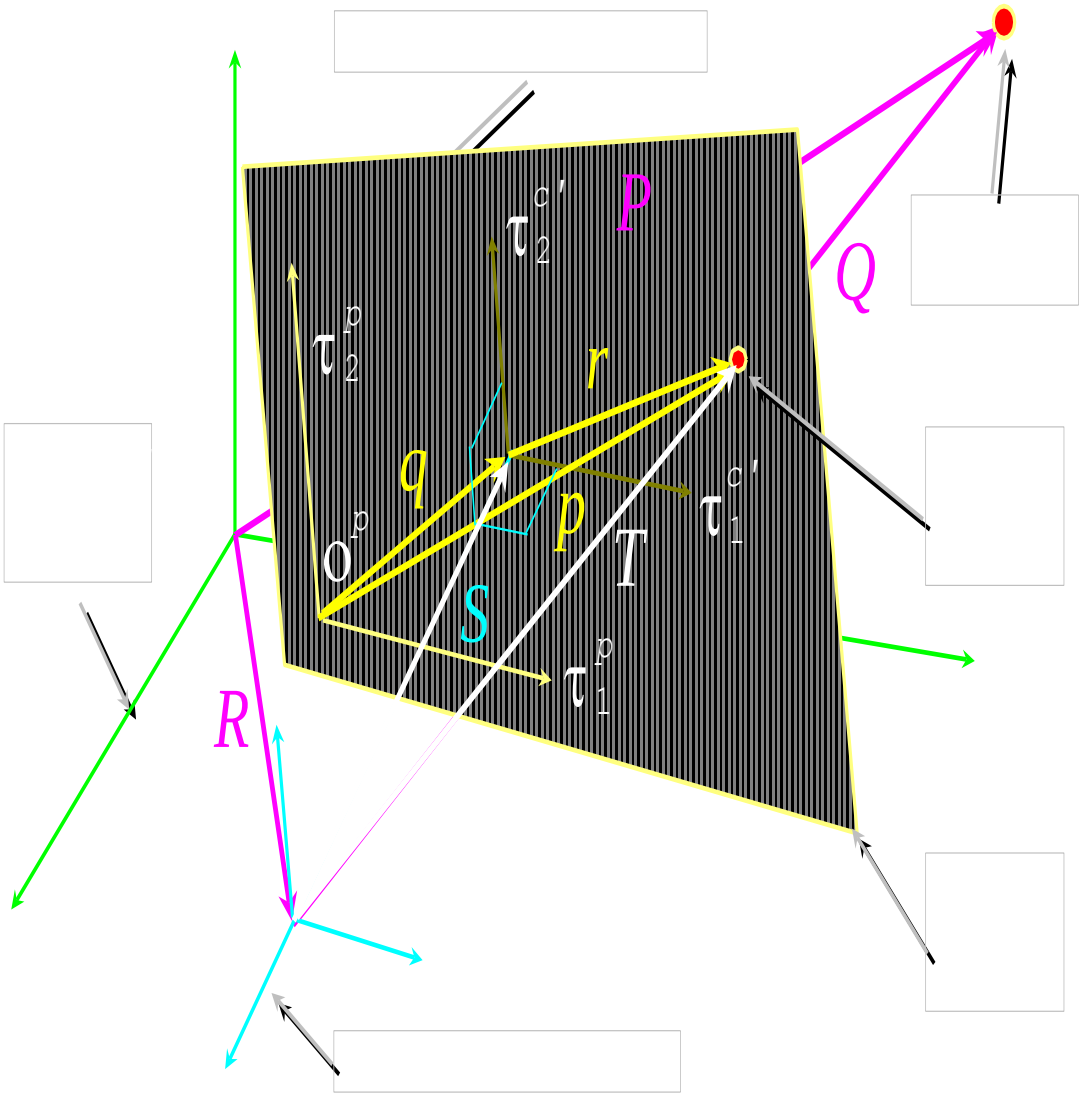


Display w .exe


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
-347.070
SOL
-460.82
TA
505.240
-1089.500
TA: 43.370 Frame# 0
76
11
2
1
10
TA
SOL
BFCL
VL
RF
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


Panning Calibration
Left calibration object
Right calibration object

Photogrammetric Physical Parameters



J Edwards, World Record in the Triple Jump – 18.29M

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

TRIPLE JUMP – World Record

During the World Championships in Athletics in August 1995 in Gothenburg Sweden, a research group had access to videotape the final of the mens triple jump. In this competition Jonathan Edwards broke the existing world record twice. The research group consisted of Per Aagaard, Morten Havkrog, Erik B. Simonsen, Gideon Ariel and Leif Dahlberg. The hop, step and jump were recorded by separate cameras with a shutter of 1/1000 sec. Later the 9 best athletes of the final were analysed by the APAS system.

trip1.avi

trip2.avi

trip3.avi

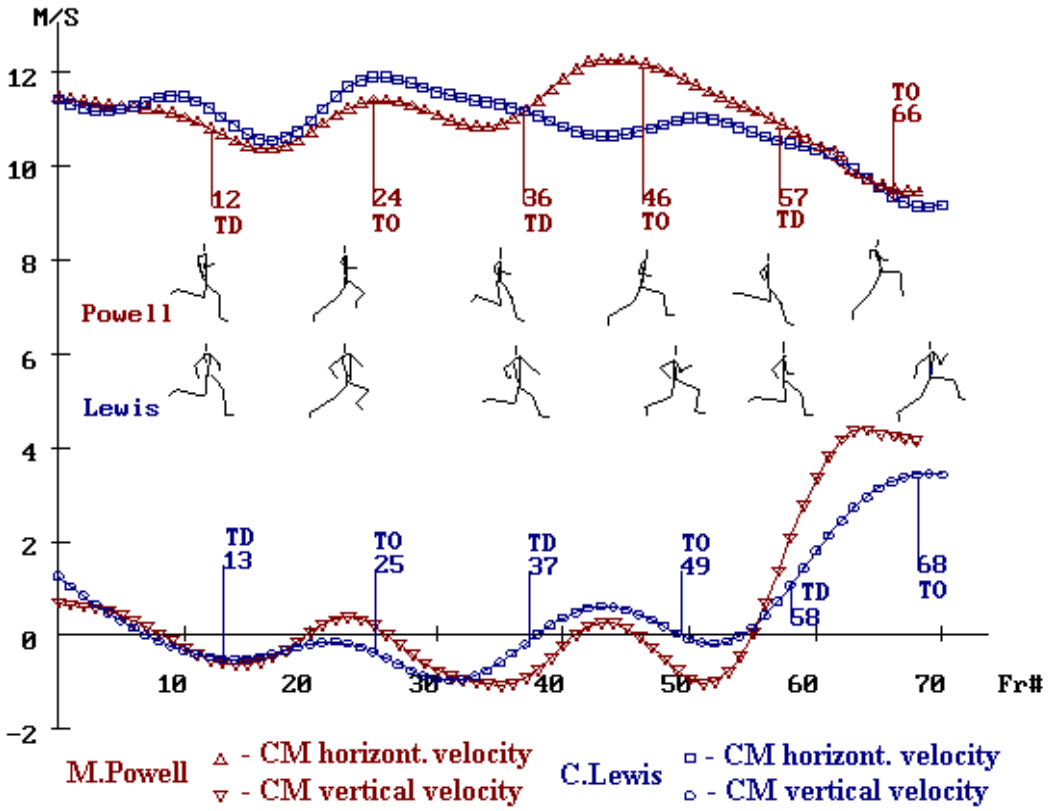
LONG JUMP TECHNIQUE: POWER OR SPEED?

A. VOROBIEV, G.B.ARIEL, I, TER-OVANESSIAN

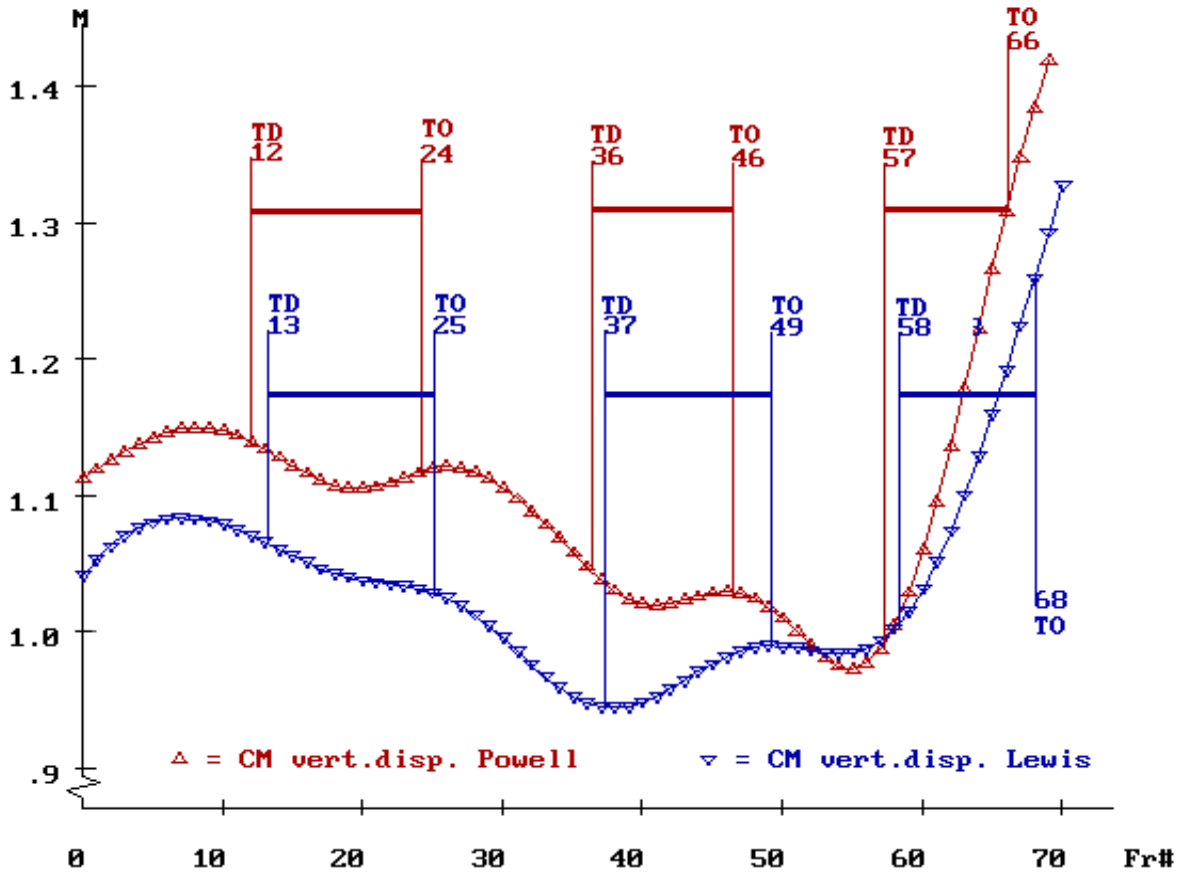
Comparative Kinematic Characteristics

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

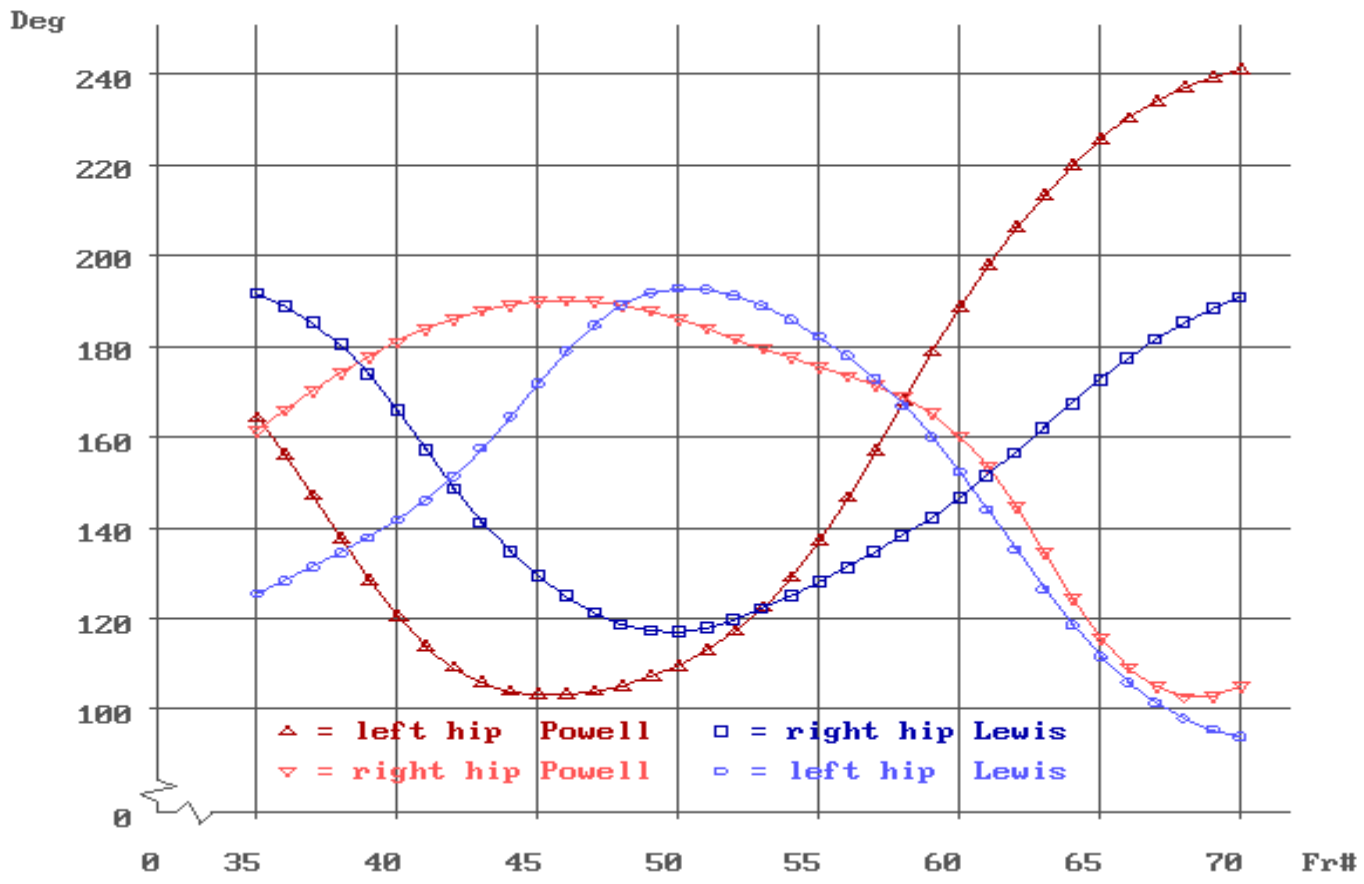
CM Velocities



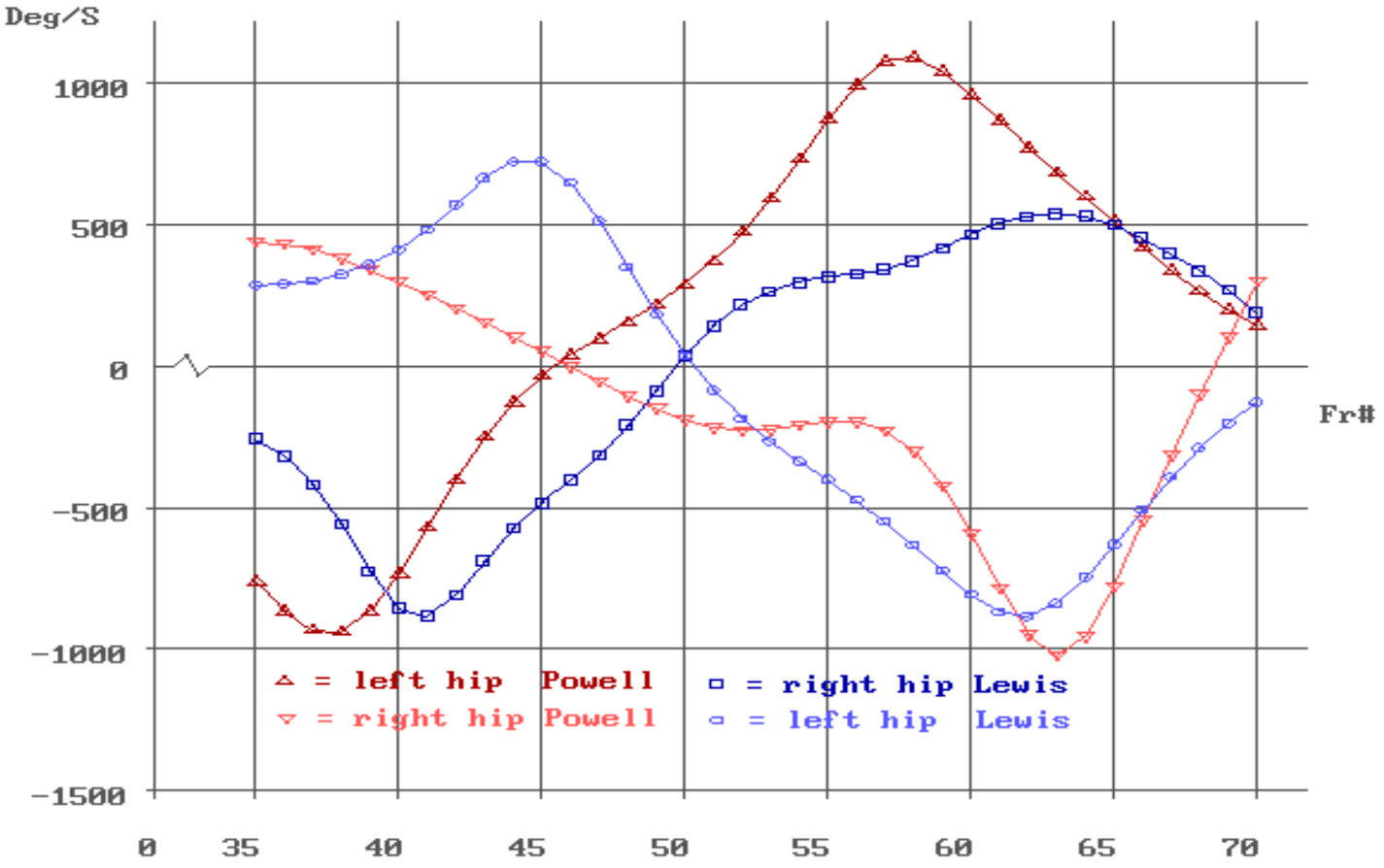
Change of the Height of CM



Angular Displacement



Angular Velocity



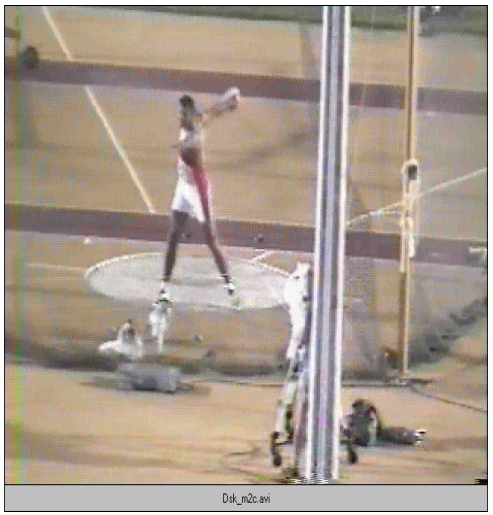
Biomechanical Analysis of Discus Throwing at Olympic Games

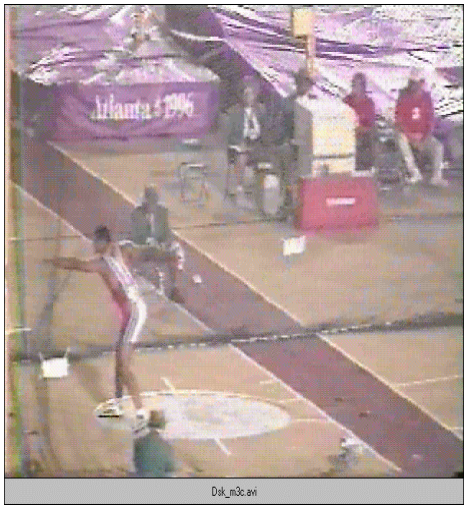
Methods

The track & field project involved collecting video records of the preliminaries and final performances of various events for the immediate development of digital movies to be uploaded on the internet.

There Were 18 Throwers During the Qualifying Round and the Best 8 Athletes Competed for the Gold Medal in the Final Round.

Video Cameras Were Placed in Several Locations to Maximize the Data Obtained for the Event

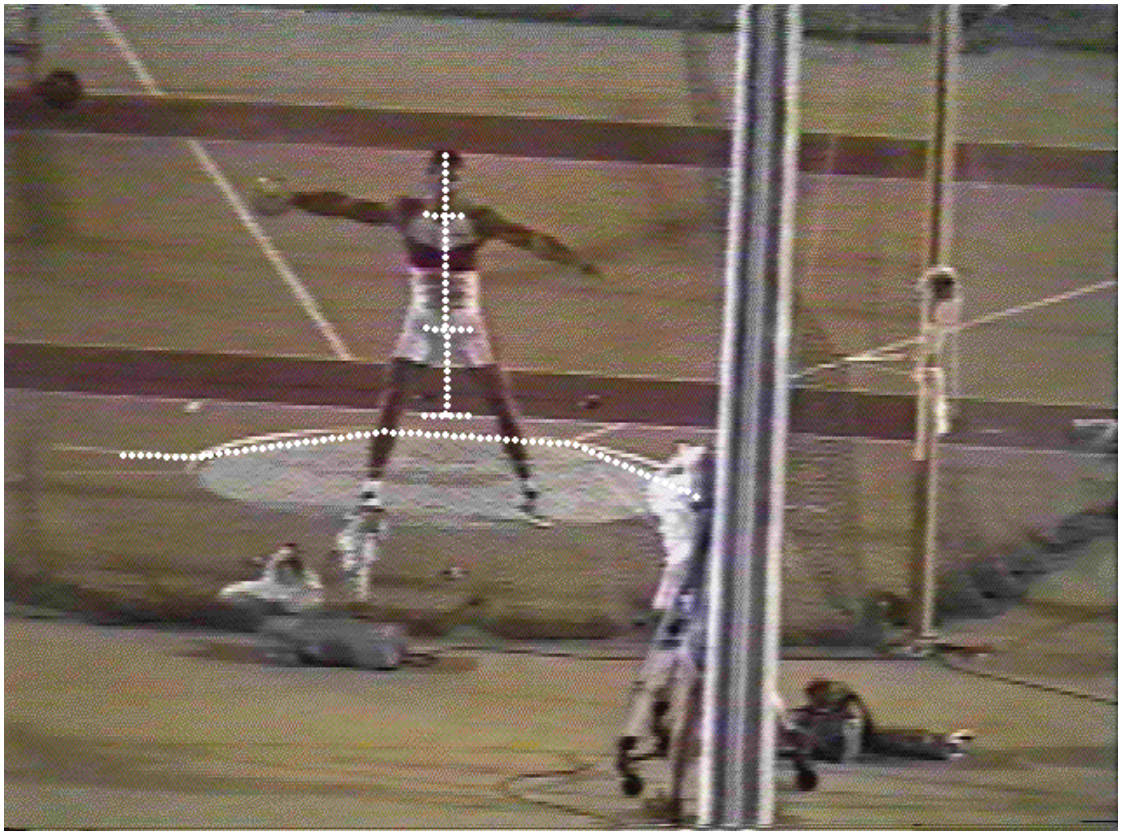




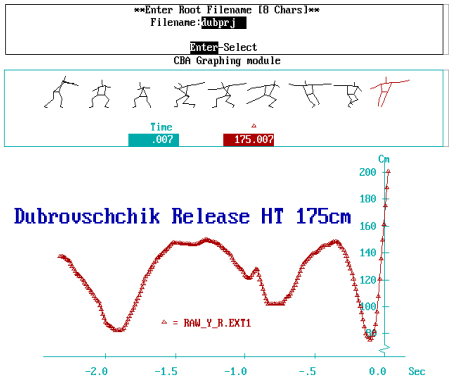
Because the Discus Throw Involves Both Linear and Rotary Motion, the Optimal Data Collection Situation Utilizes at Least Three Cameras Placed Appropriately So That None of the Athlete's Motion Is Obscured

Dimensions of Known Factors and Various Other Measured Objects in the Field of View Were Used for the Calibration Points

3-D DLT Composite Control Cube



Results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Filename:dubprj
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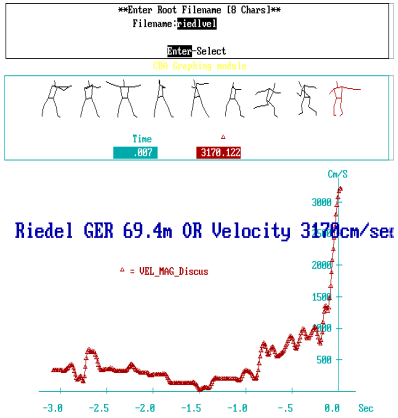
CBA Graphing module
Time
.007
175.007
Cm
Dubrovschchik Release HT 175cm
△ = RAW_Y_R.EXT1
Sec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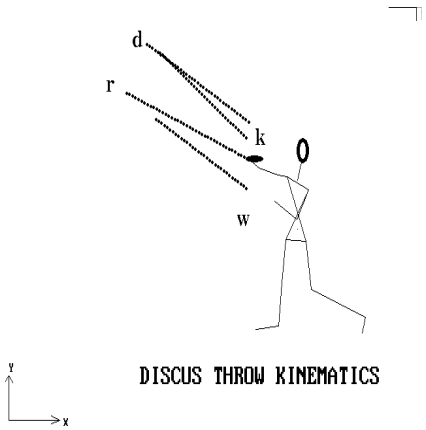
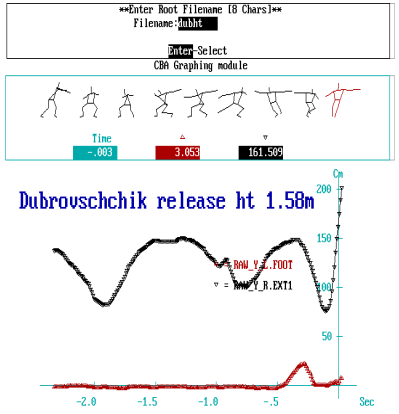
Cm/S
Riedel GER 69.4m OR Velocity 3170cm/sec
△ = VEL_MAG_Discus
Sec


d
r
k
O
w
DISCUS THROW KINEMATICS
Y
X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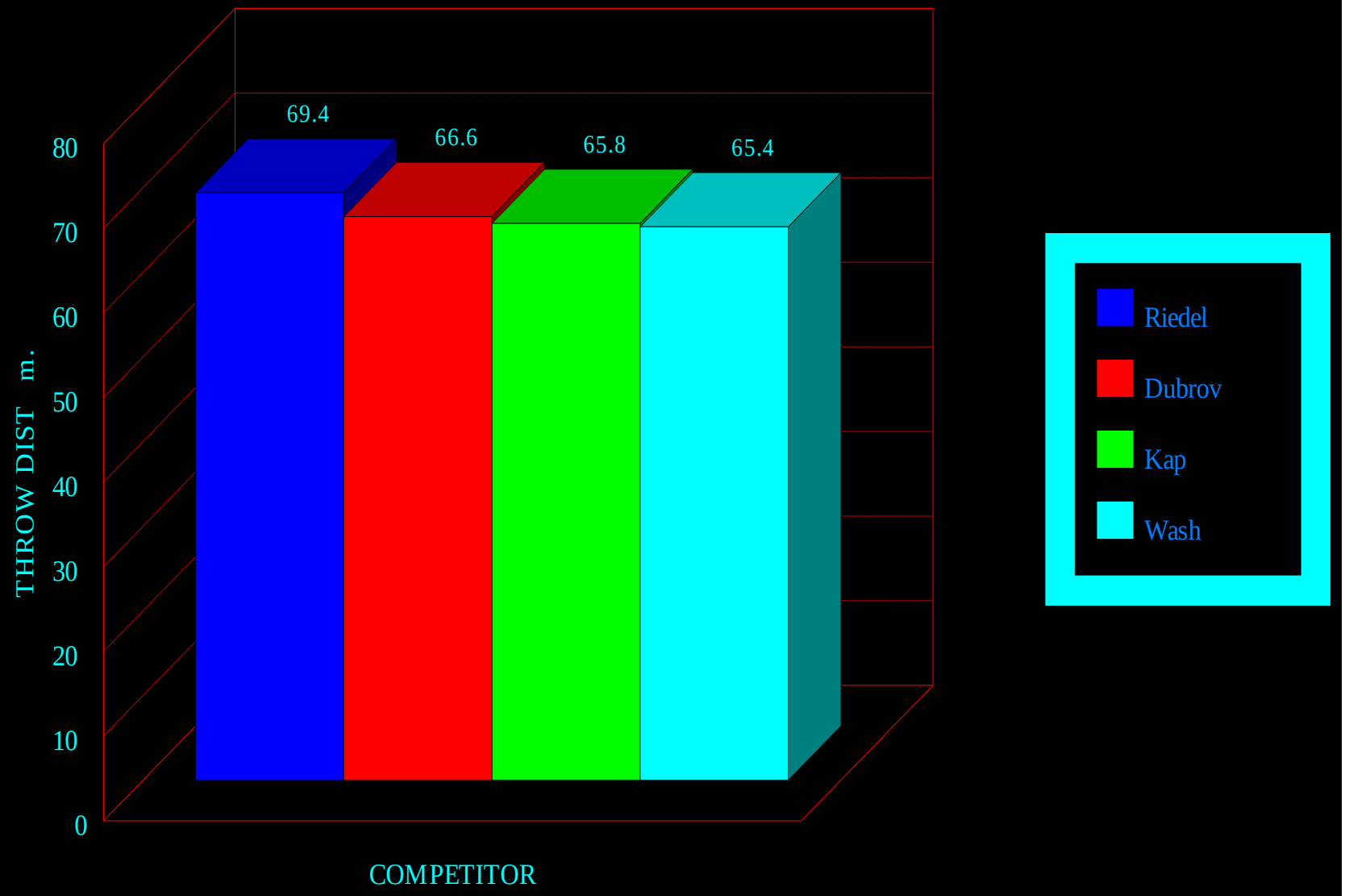
Enter-Select
CBA Graphing module
Time
-.003
3.053
161.509
Cm
Dubrovschchik release ht 1.58m
▽ = RAW_Y_R.EXT1
Sec

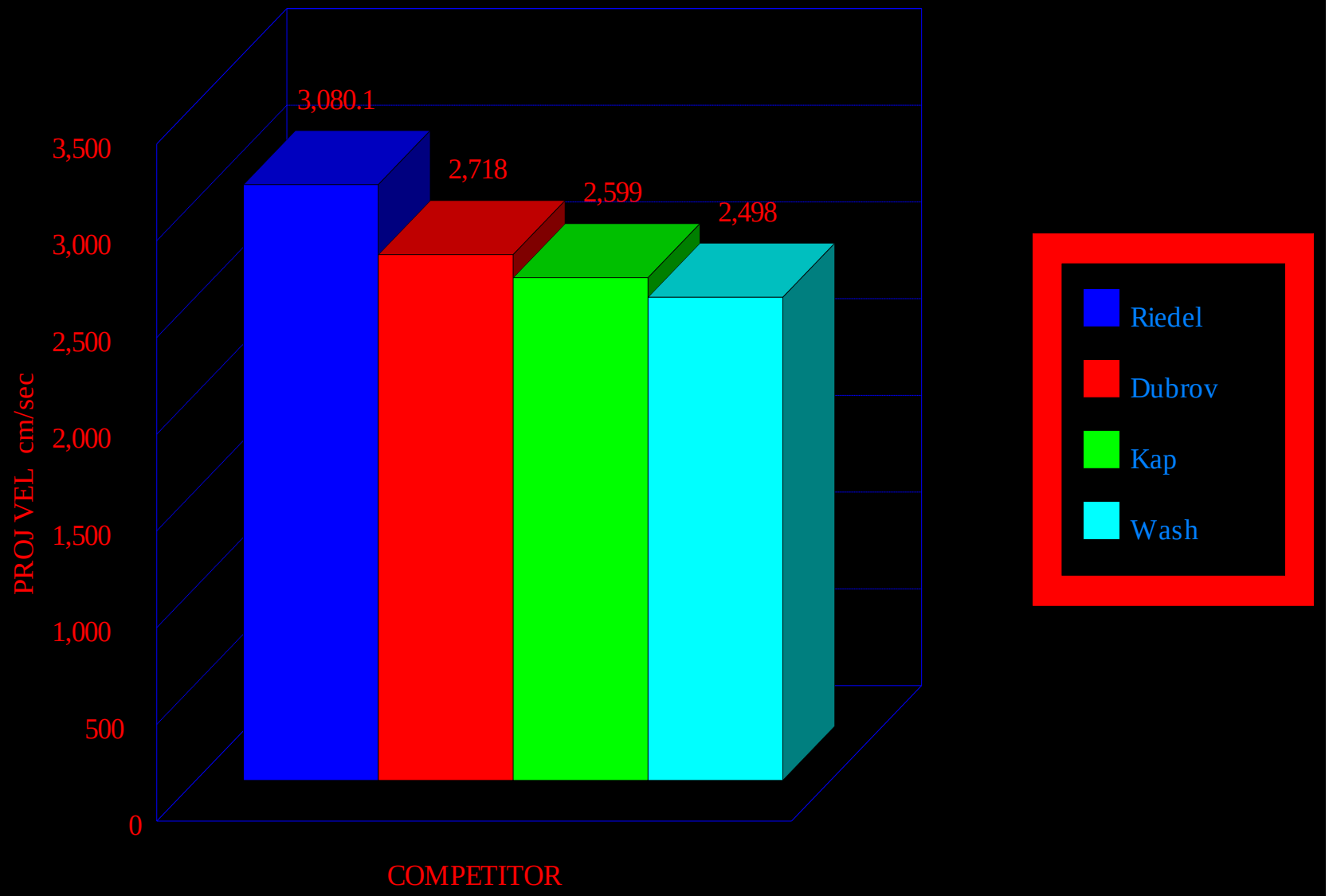
Washington Throwing Kinematics

Attempt	Distance m.	Velocity $cm \bullet sec^{-1}$	Projection Angle rad (deg)	Release HT cm	Move Time sec
Best Throw	65.4	2541 V_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%

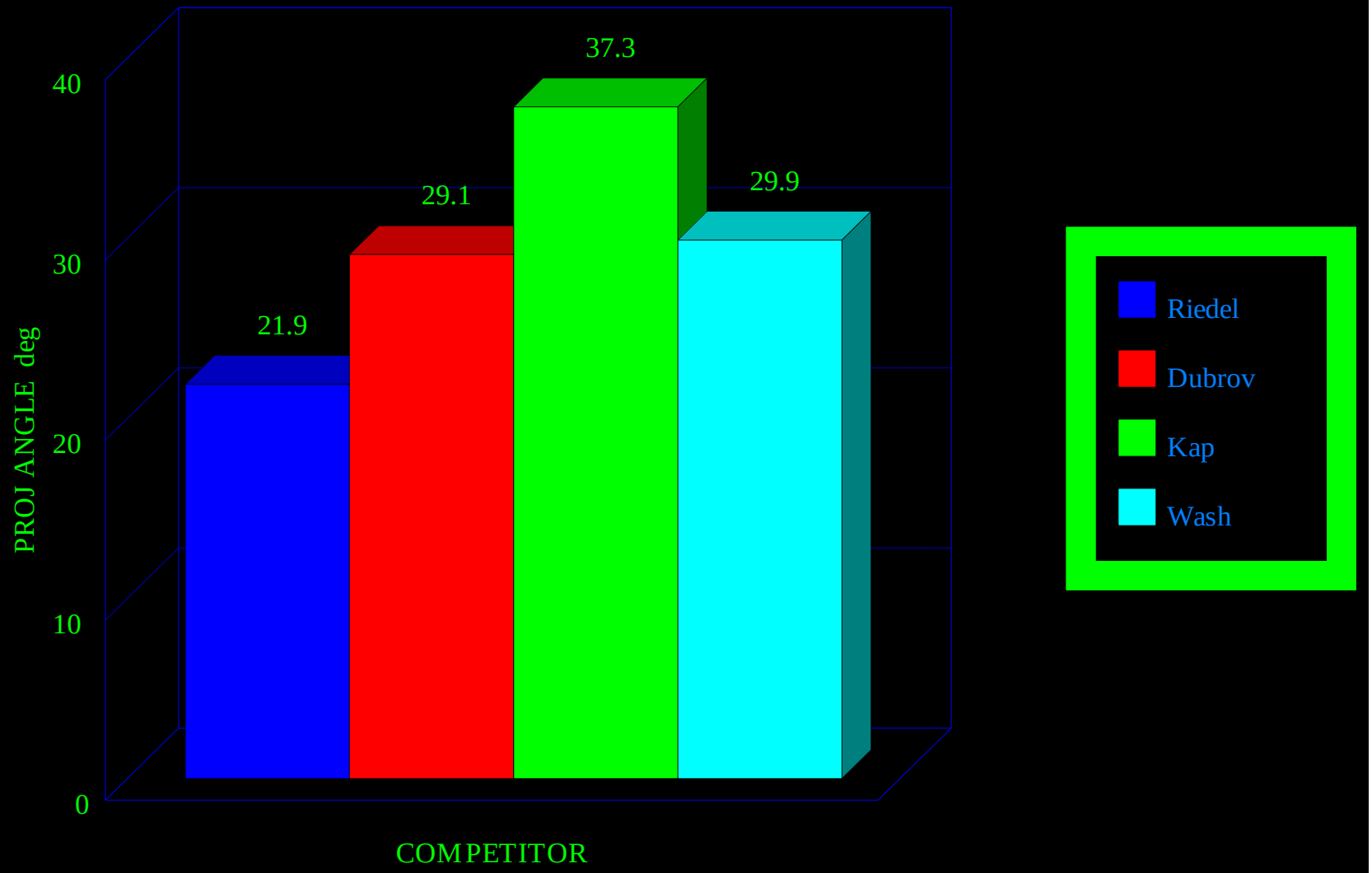
DISCUS THROW DISTANCE m.



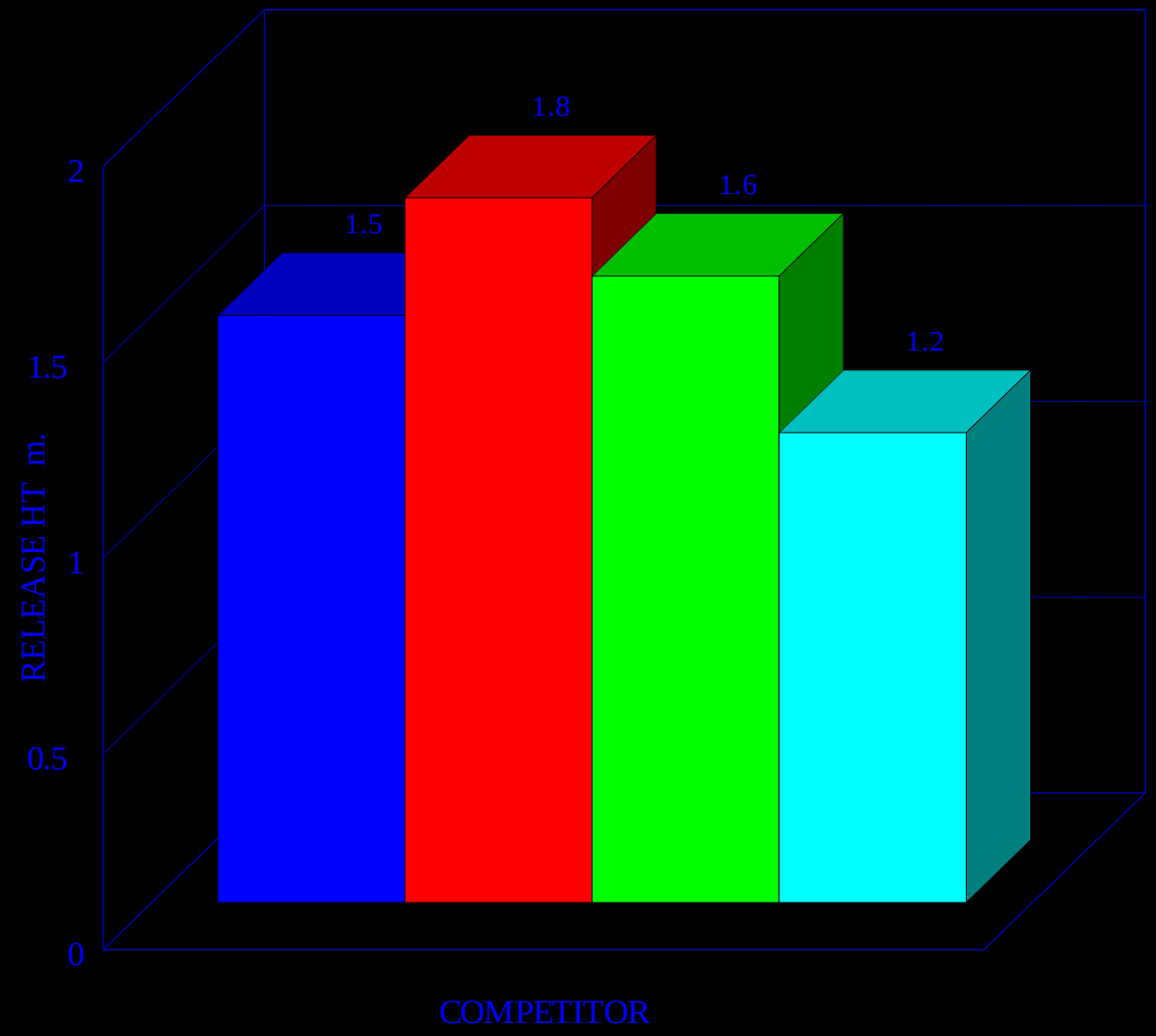
DISCUS PROJECTION VELOCITY cm/sec



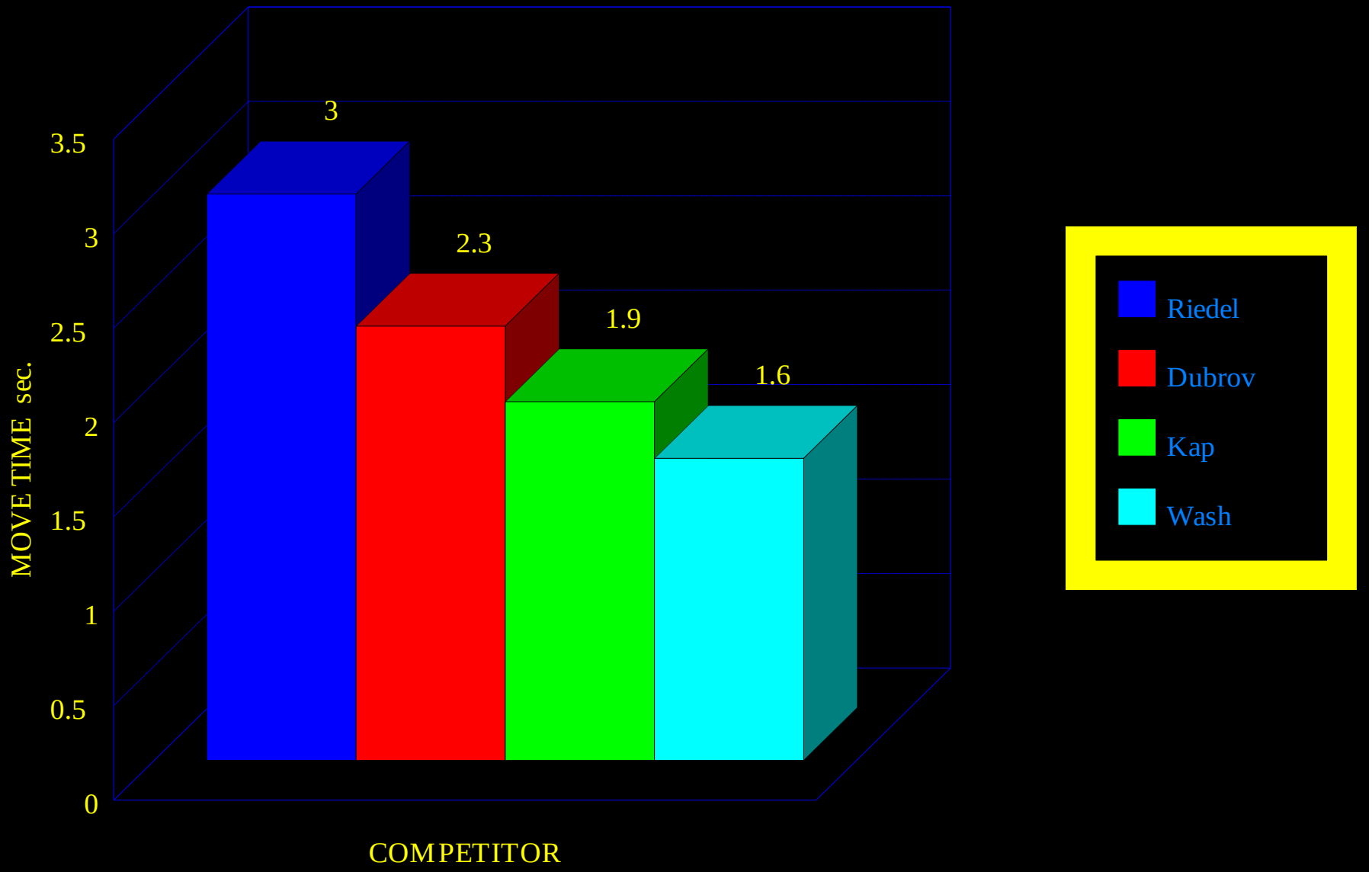
DISCUS RELEASE ANGLE deg



DISCUS RELEASE HEIGHT m.

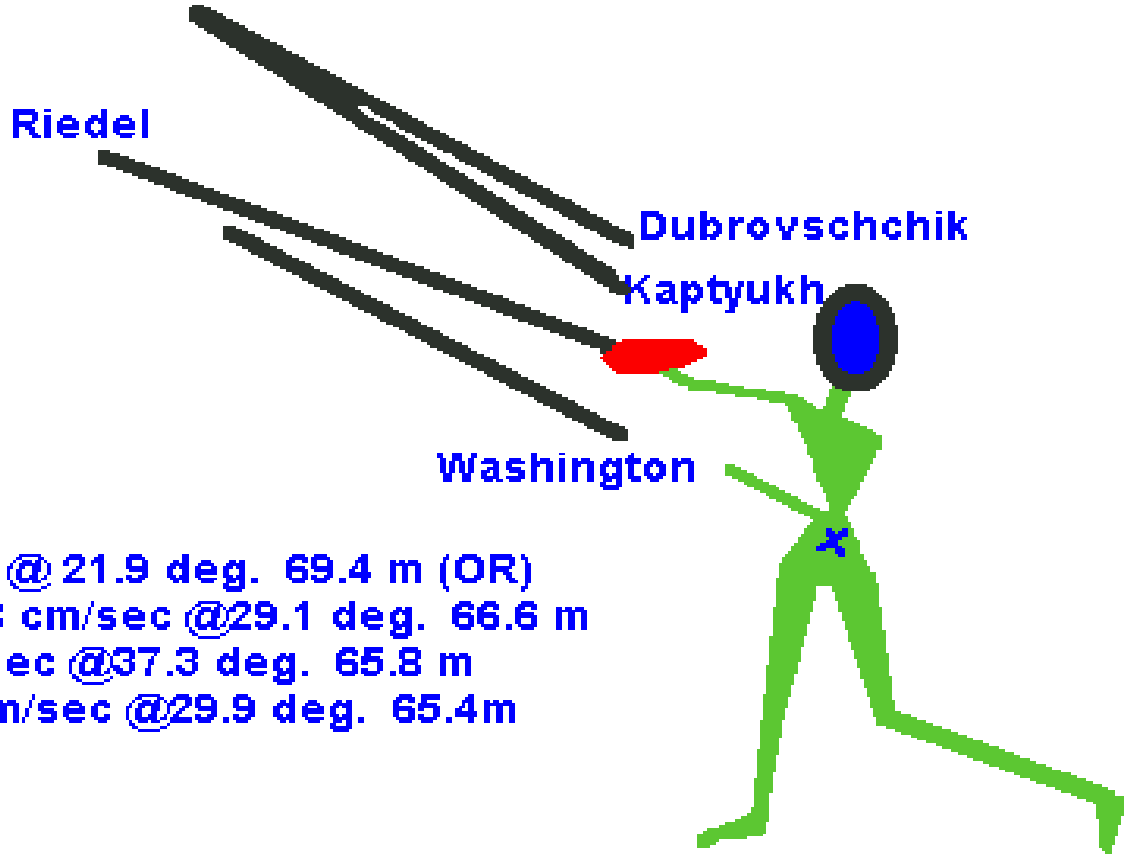


DISCUS MOVEMENT TIME sec.

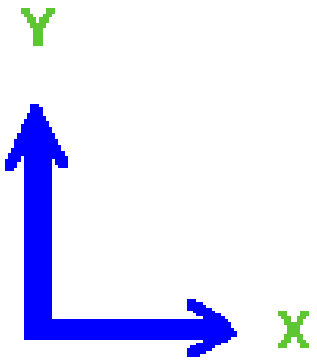


Throwing Kinematics for Top Four Discus Performers at 1996 Atlanta Olympics

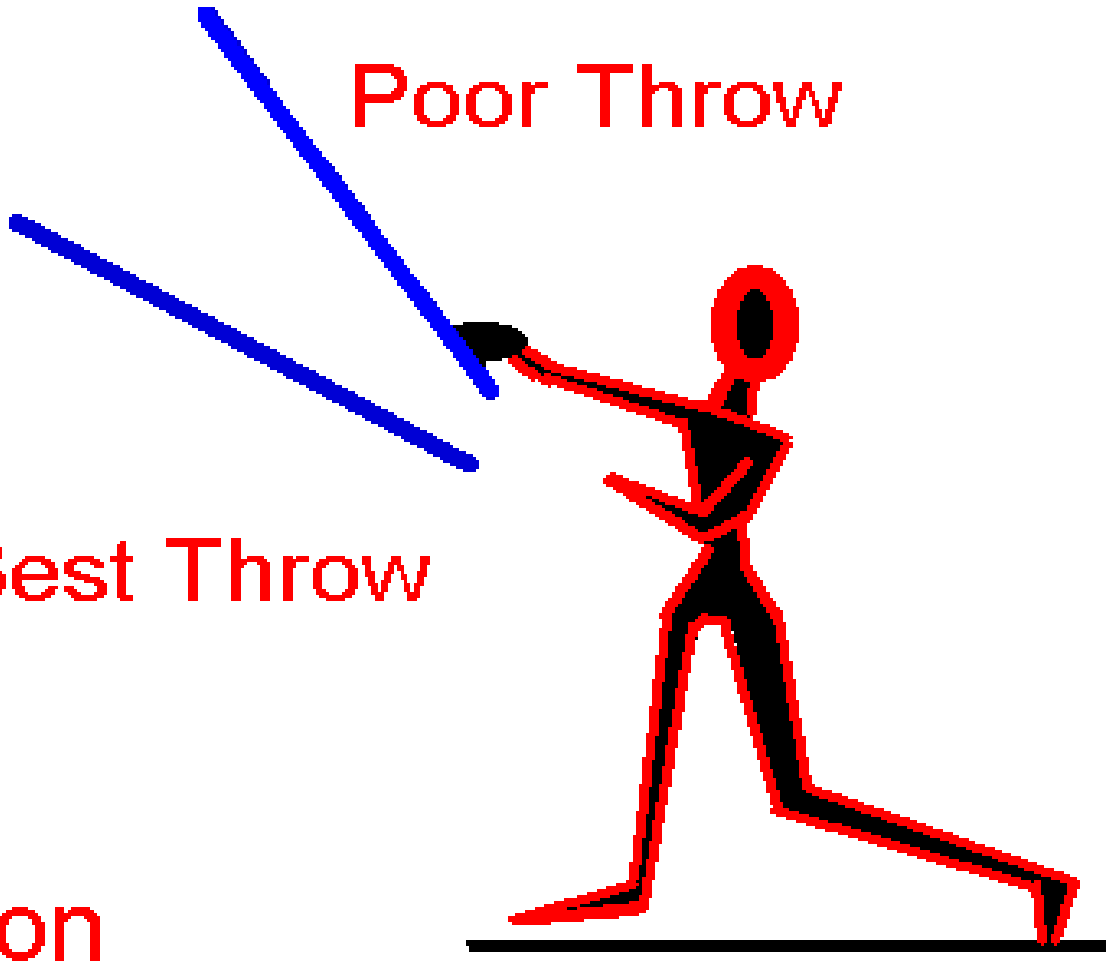
Riedel (Ger)	69.4	3080.1	21.9	1.5	3.0
Dubrovschchik (Blr)	66.6	2718.5	29.1	1.8	2.3
Kaptyukh (Blr)	65.8	2599.0	37.3	1.6	1.9
Washington (USA)	65.4	2498.0	29.9	1.2	1.6



Riedel 3080 cm/sec @ 21.9 deg. 69.4 m (OR)
Dubrovschchik 2718 cm/sec @29.1 deg. 66.6 m
Kaptyukh 2599 cm/sec @37.3 deg. 65.8 m
Washington 2498 cm/sec @29.9 deg. 65.4m

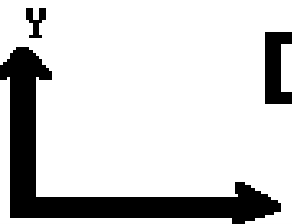


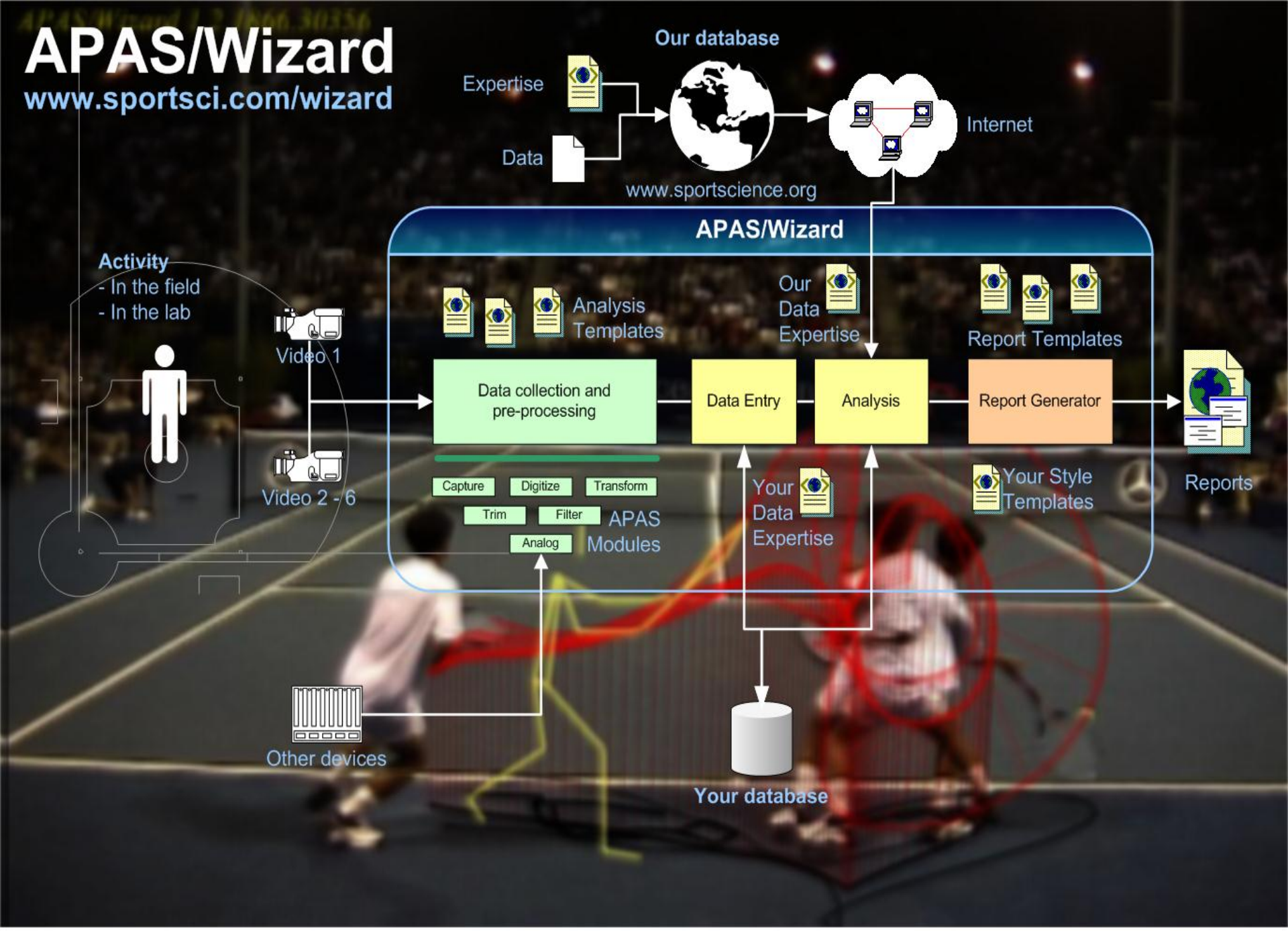
DISCUS THROW KINEMATICS



Washington

DISCUS THROW KINEMATICS




APAS/Wizard
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Expertise
Data
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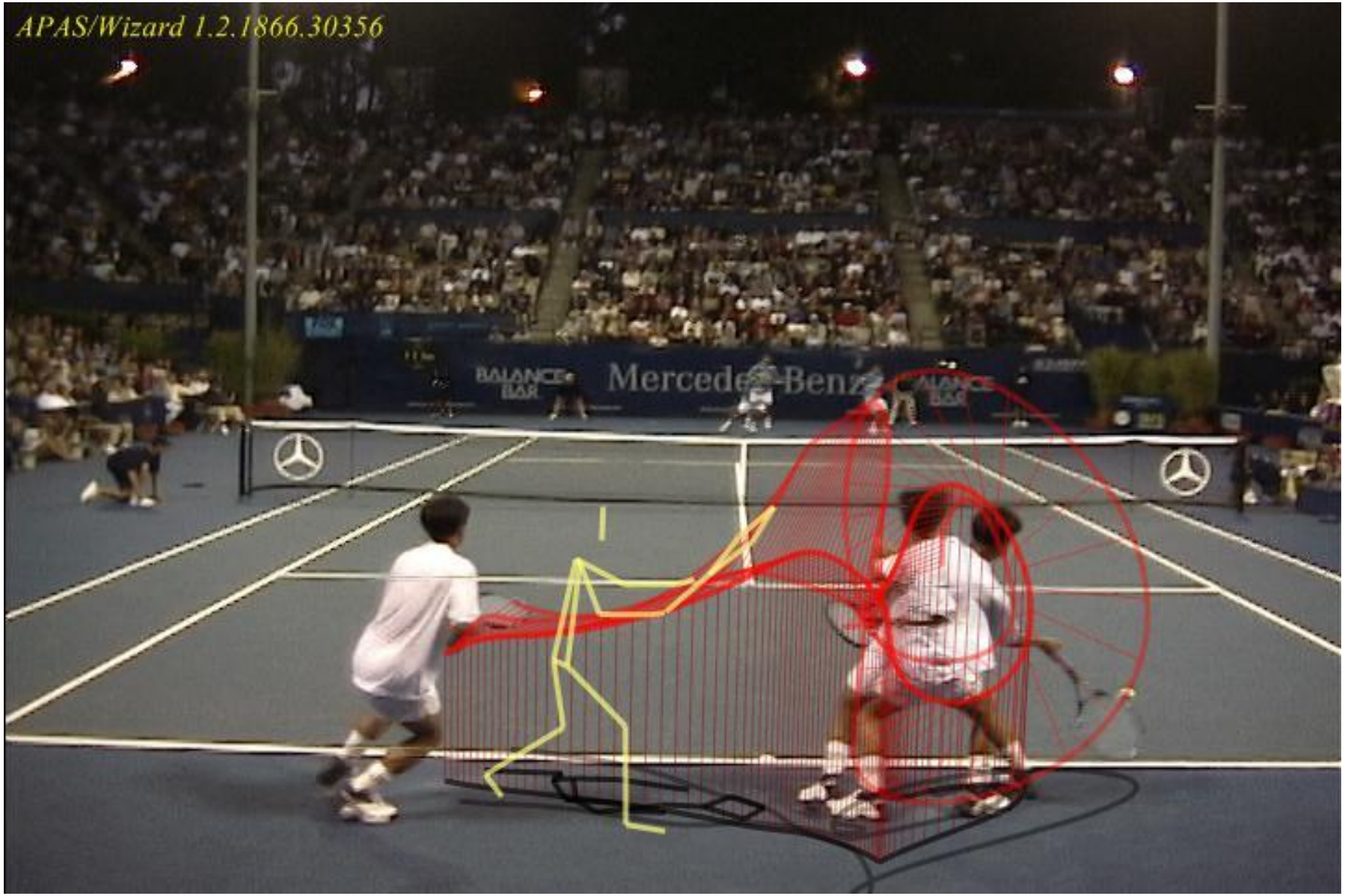
Activity
- In the field
- In the lab
Video 1
Video 2 - 6
Analysis Templates
Our Data Expertise
Report Templates
Data collection and pre-processing
Data Entry
Analysis
Report Generator
Reports
Capture
Digitize
Transform
Trim
Filter
Analog
APAS Modules
Your Data Expertise
Your Style Templates
Other devices
Your database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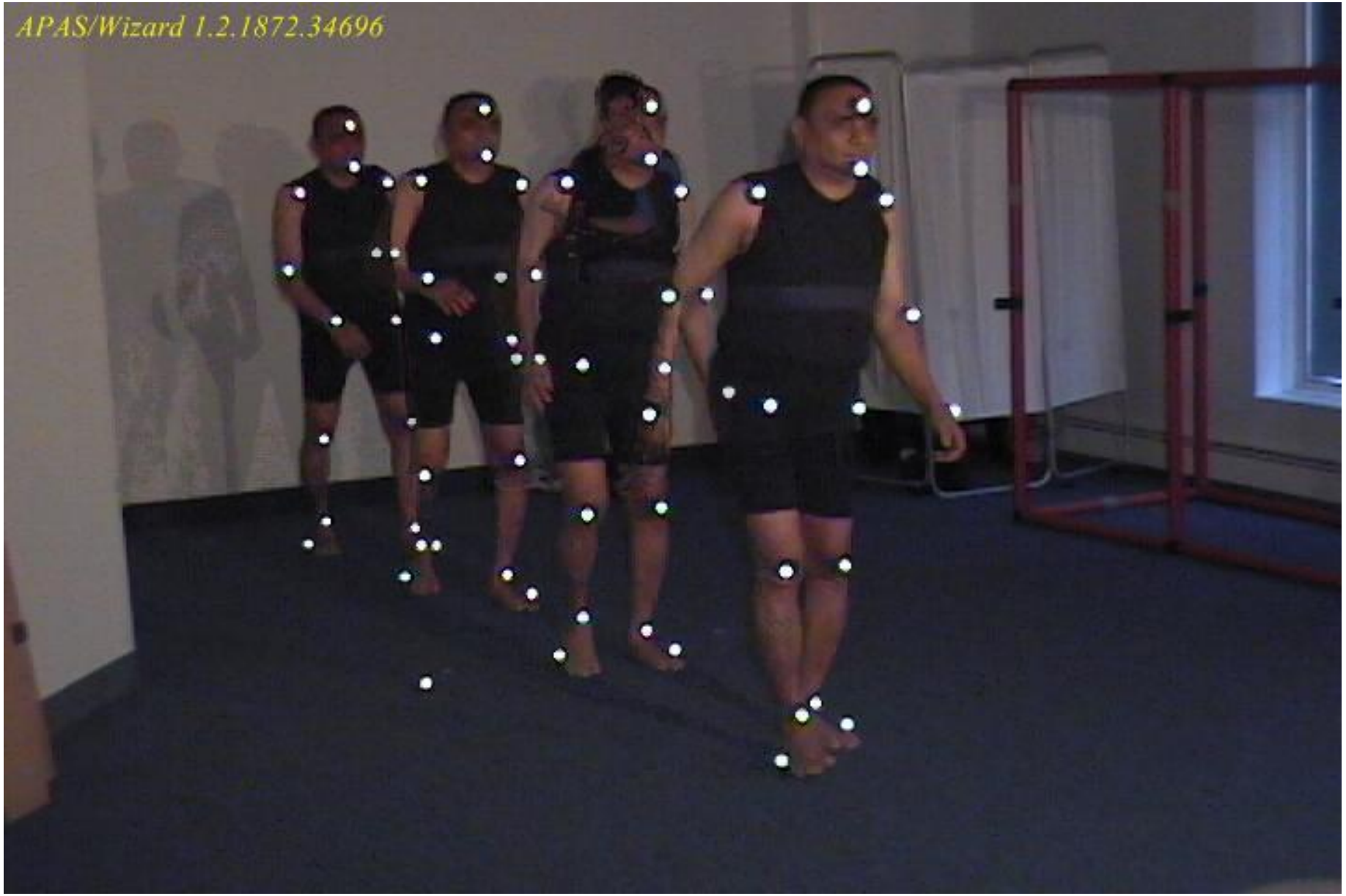
BALANCE BAR
Mercedes-Benz
BALANCE BAR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APAS/Wizard 1.2.1872.35193
BALANCE
BAR


APAS/Wizard 1.2.1872.35193
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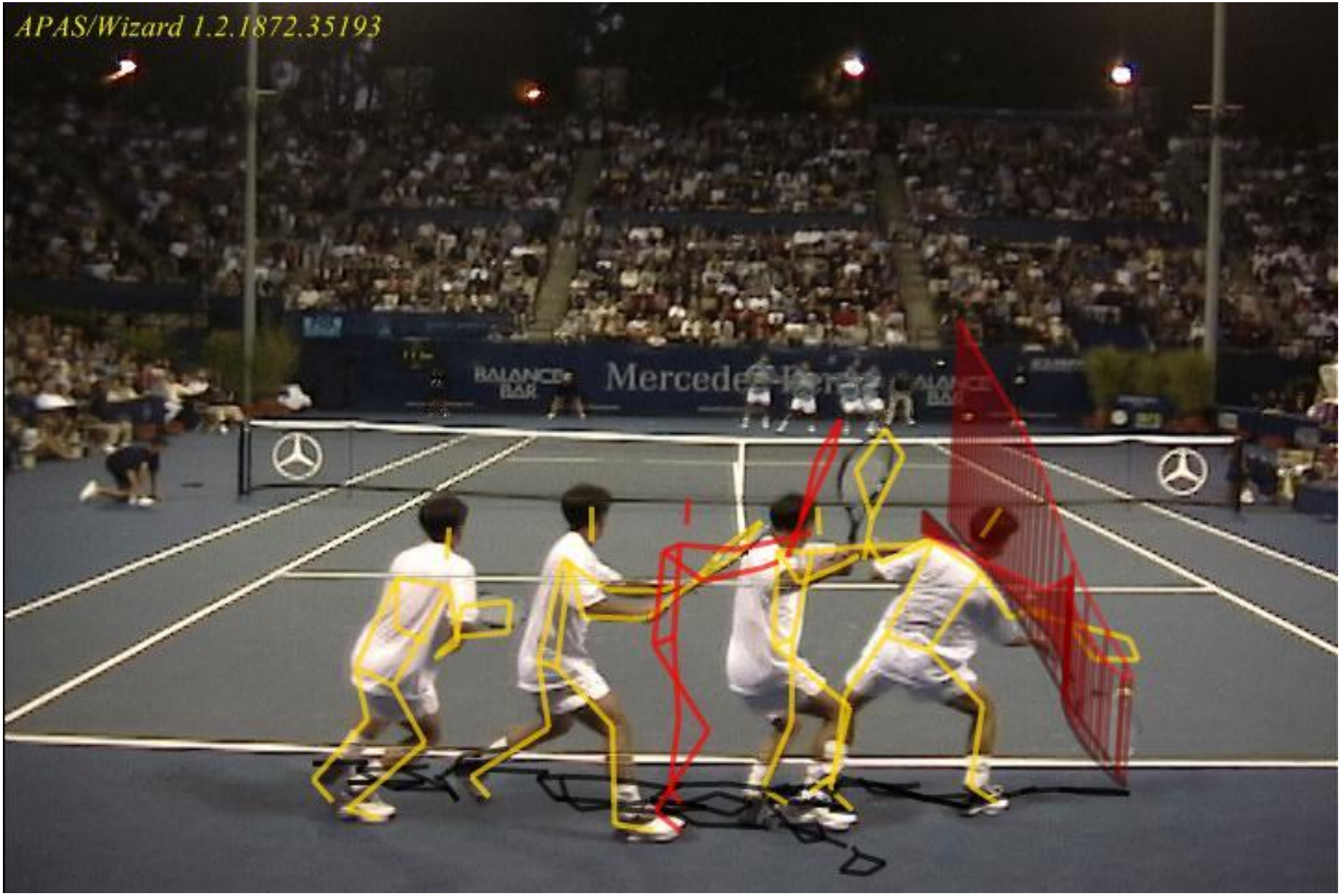
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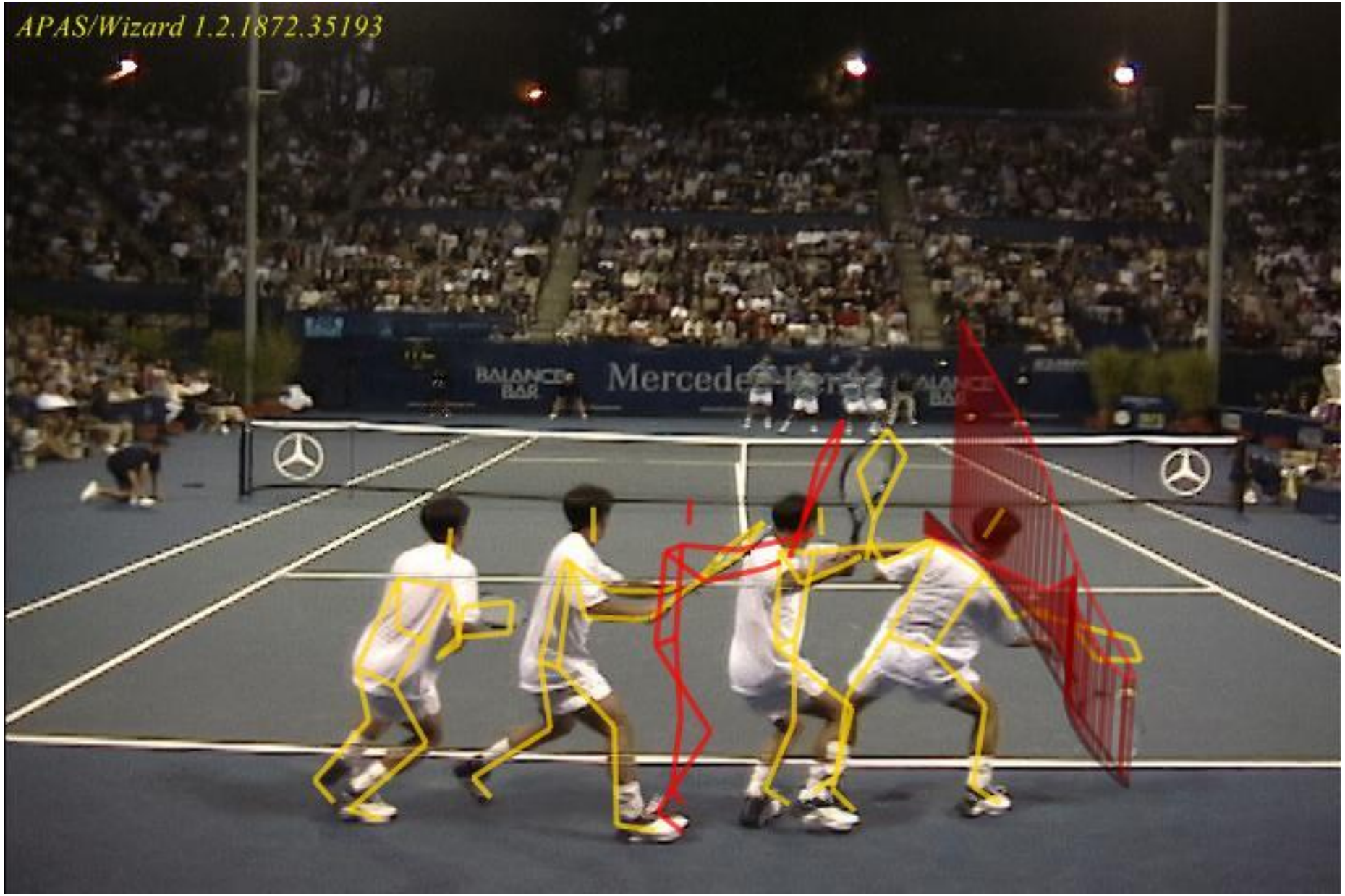
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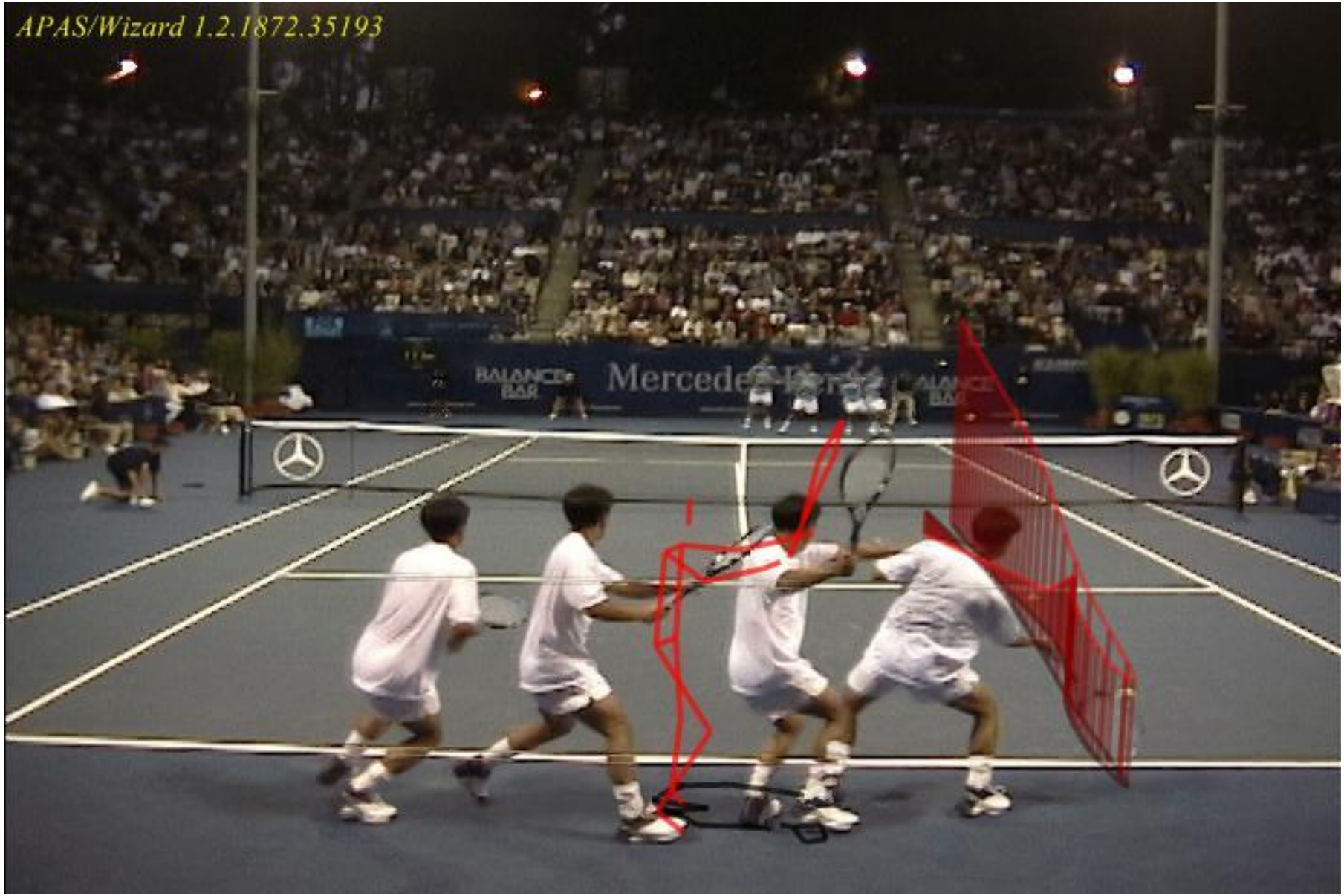
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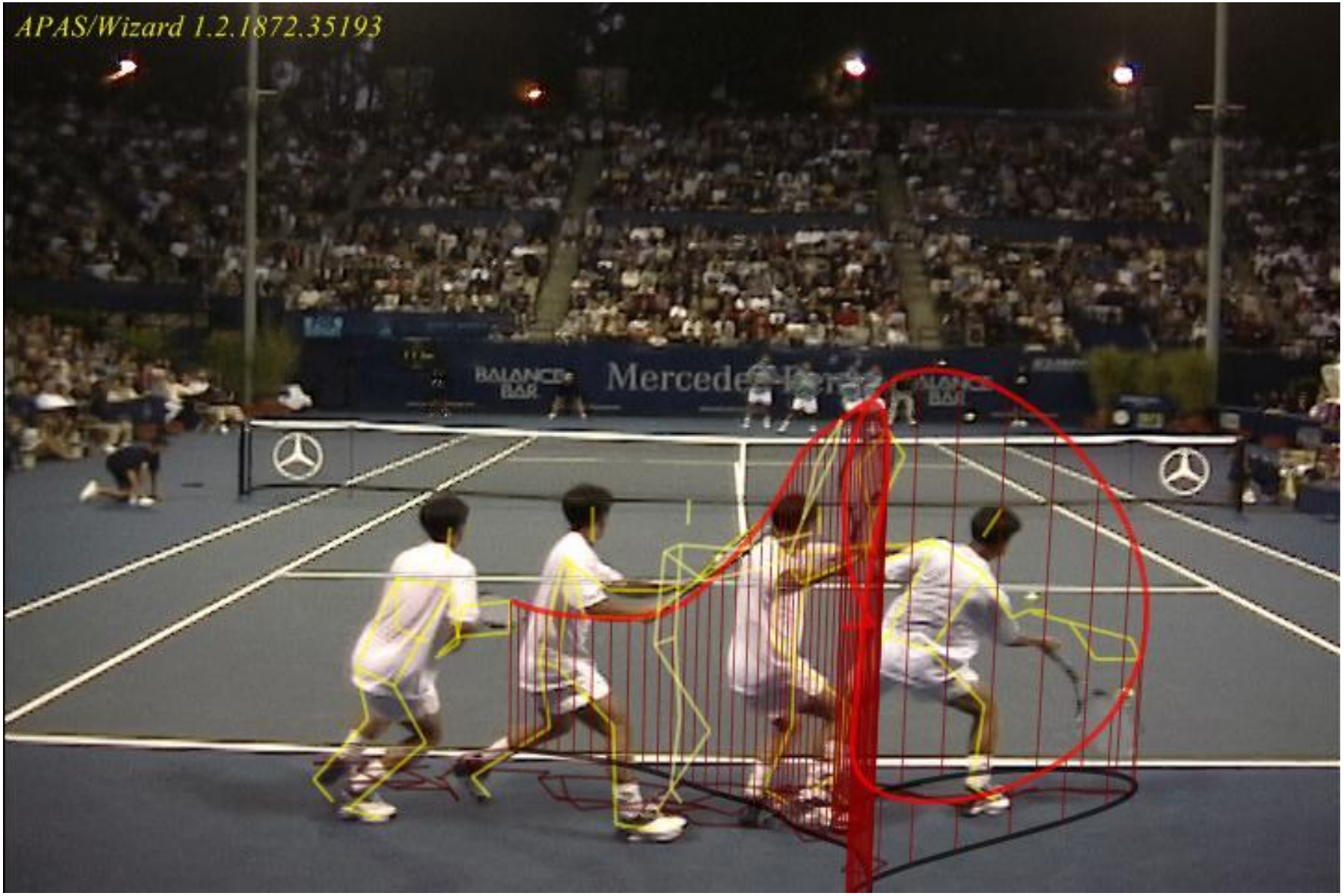
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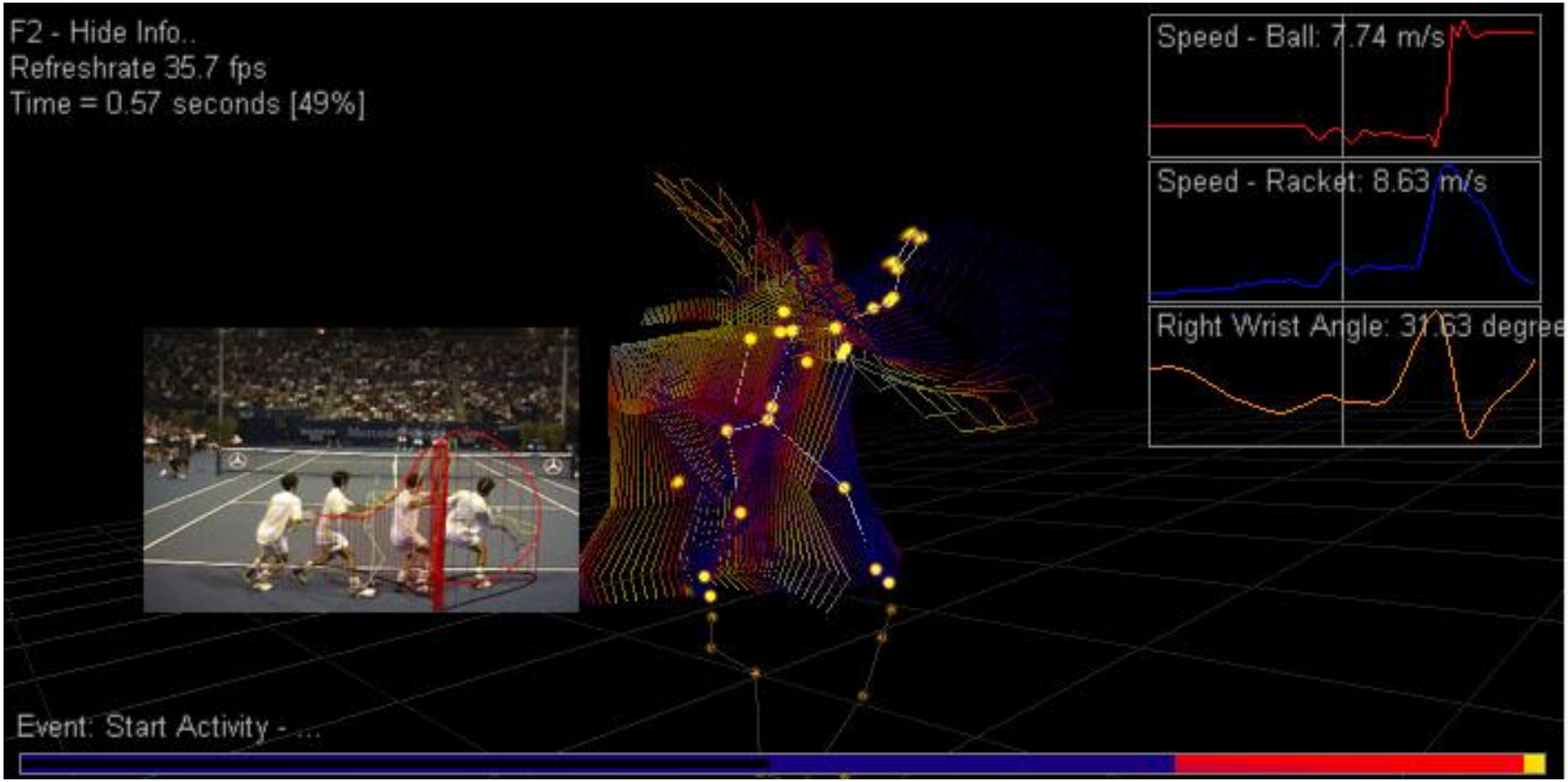
BALANCE BAR


F2 - Hide Info..
Refreshrate 35.7 fps
Time = 0.57 seconds [49%]
Speed - Ball: 7.74 m/s
Speed - Racket: 8.63 m/s
Right Wrist Angle: 31.63 degree
Event: Start Activity - ...

What are the requirement and steps in Purchasing a new Biomechanical System

- Set your objectives for Analysis
- System Tryout
- Perform a full project with the tryout system
- All hardware must be off the shelves
- Hardware must be made in China
- Software must be downloadable
- Upgrades must be free
- Workstations must be added to the system
- Price must be realistic

Only the APAS System meets these objectives

THANK YOU