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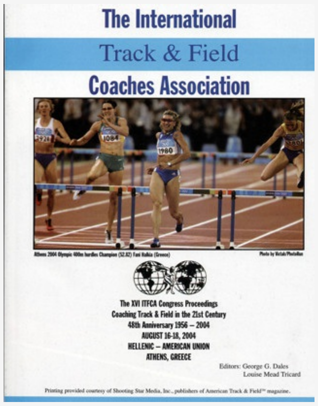
# Great Technological Advance at the Olympic Games

## High Technology used in the Olympic Games

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|---|---|
| **Code** | **adi-pub-01267** |
| **Title** | Great Technological Advance at the Olympic Games |
| **Subtitle** | High Technology used in the Olympic Games |
| **Name** | International Coaches Association |
| **Author** | Gideon Ariel |
| **Published on** | Monday, August 16, 2004 |
| **Subject** | Biomechanics; Journal |
| **URL** | https://arielweb.com/articles/show/adi-pub-01267 |
| **Date** | 2013-01-16 15:40:51 |
| **Label** | Approved |
| **Privacy** | Public |

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Below find a reprint of the 12 relevant pages of the article "Great Technological Advance at the Olympic Games" in "International Coaches Association":

# The International
# Track & Field
# Coaches Association

Athens 2004 Olympic 400m hurdles Champion (52.82) Fani Halkia (Greece) Photo by Victah/PhotoRun

**The XVI ITFCA Congress Proceedings**
**Coaching Track & Field in the 21st Century**
**48th Anniversary 1956 – 2004**
**AUGUST 16-18, 2004**
**HELLENIC – AMERICAN UNION**
**ATHENS, GREECE**

Editors: George G. Dales
Louise Mead Tricard

Printing provided courtesy of Shooting Star Media, Inc., publishers of American Track & Field™ magazine.

# The Great Technological Advance at the Atlanta 1996 Olympic Games

Gideon Ariel, Ph.D. Coto Research Center, USA

From 1968 to the early 90s, the existing technology for collecting data and analyzing performance required lots of manual work. In the early 90s we began automating this process. For the first time miniature cameras and small computer notebooks with great power allowed us to collect data and provide results in a few minutes.

The most dramatic changes occurred at the Atlanta 1996 Olympic Games. The main research goal was to analyze the Track and Field performances, including the immediate task of uploading the data to the Internet in the fastest, nearly real time. In this way, scientists, students, coaches, athletes or any interest group were able to immediately download the video and other data from the Internet. Prior to the Olympics, this author made various presentations explaining some of the processes. These are new and innovative procedures which allow the immediate transmission of video information around the world for analysis at different locations.

These video clips, with the proper calibrated objective information, allowed a full biomechanical analysis of the event. Most biomechanical analyses require a motion analysis system for transforming and filtering the raw data as well as additional processing to yield kinematic data such as displacements, velocities and accelerations. Biomechanical quantification can be organized to allow full interpretation of the event providing the coach with valuable data for present and future improvement. Such understanding and information can be useful for novice, elite or veteran athletes for optimizing their performances.

Accessibility to the athletic performance sites were justifiably strict so that the Games would be safe for all of the athletes and spectators. These security procedures were gratefully endorsed and were adhered to willingly. Indeed, special locations for setting the video cameras had to be chosen to accommodate these security needs. For the 1996 study, as many as nine video cameras were used to collect data for most of the Track and Field preliminary and final events. (Attempts were made to block this data acquisition and dissemination; these efforts were politically motivated and will be discussed elsewhere.)

The immediate goal was realized as the video data for each event was uploaded to the Internet. The procedure was to collect the video data at the performance venue, process it almost immediately, and upload the files to the Internet for worldwide access. Tracking results indicated, subsequently, that thousands of data sets were downloaded by various organizations around the world ranging from school children in New Jersey to sheep farmers in New Zealand. For the first time in the era of the modern Olympics, the Internet was used to share data in almost real time. Ariel Dynamics Inc. created a special Web Site to allow the rest of the world to sign on to the special Web Site for the Olympic Games at no cost. (Add link to the Atlanta Web link)

The first study completed utilized all of the data collected during the preliminaries and finals for the Men's Discus Throw. The results were presented to the U.S. Olympic Training Camp for the Men's Discus Throwers in San Diego, California in November, 1996. (See Fig. 10)

At the meeting, the results were disclosed, interpreted and discussed with the athletes. The discussions among the coaches, athletes and scientists created very effective environments to learn the advantages and disadvantages of the event. The knowledge gained was based upon the performances by the world's best throws executed during the Atlanta Games. Understanding performance from data gleaned from actual event throws is more realistic and therefore, more helpful to the athletes than basing conclusions obtained only during practice sessions.

During the last two decades, enormous progress has been made in the field of biomechanical instrumentation. The introduction of the first electronic digitizer constituted a significant improvement to existing methods and replaced the traditional tracing technique which employed paper, pens and mirrors. Prior to 1968, manual processes involved in biomechanical quantification were slow, tedious and frequently contaminated with arithmetic error. Subsequently, computerization of many of these steps has accelerated the growth and widespread acceptance of biomechanical applications.

One of the first applications of these computerized innovations occurred in the area of Olympic athletic competition:

1. The electronic digitizer not only decreased the time



needed for locating and storing joint center coordinates, but also reduced many of the tracing and measurement errors.
2. In addition, computers allowed data-gathering and analysis of biomechanical data to occur in different locations.

The "digitizing" process could thus be conducted at one location and the digitized points transferred on-line to the time sharing system on a main frame computer for further processing. However, although this milestone represented a giant leap in precision and productivity, the limitations of the mainframe computer's architecture severely limited the public's access to this new form of technology.

Computers have evolved, and taken on new forms, capacities and applications. Mainframe-based data processing has since given way to client/server computing over a variety of local and wide area networks. The advent of the Internet and the commercialization of the World Wide Web have opened up new horizons never before imagined in many high tech areas involving science, business and engineering. Simultaneously, rapid advances in video and multimedia technology have made possible the presentation of information in much more natural, lifelike and easily comprehensible ways, such as, three-dimensional and virtual reality images.

The new generation of computers and the Internet have opened new frontiers for research and international cooperation on multifaceted studies including the field of Biomechanics. Biomechanical usage gradually migrated from athletics to space and sports medicine and further extended its impact into industrial design and general medical practice. With rapid advances in networking, communications and presentation technology, it is now possible to make the benefits of biomechanics much more accessible to a wider audience and a greater range of applications.

Although the restrictions due to geographical distance, time discrepancies and relatively slow throughput over analog phone lines still pose some limitations, the use of the Internet and multimedia promises to greatly facilitate the acquisition of x, y coordinates and enhance cooperative research efforts. One technique for acquiring motion coordinates, that is "digitizing" on the Internet, has been developed for the purpose of facilitating research inquiries.

The purpose of one early test study was to evaluate a newly developed technology for digitizing between remote sites using the Internet as the communication medium. In other words, the video sequences resided on one computer and the remote site was responsible for securing the x,y coordinates through on-line processing. The sport selected for that test was golf and the subjects were evaluated using a driver.

The video sequence was "grabbed" or "captured" using a frame-by-frame advance VCR. The video data was stored in AVI format on a computer located at Site while the digitizing computer, remote sites, resided at a distance around the world. The first step was determination which specific portion of the performance to be selected for subsequent analysis. Although the actual digital data was stored on the computer located at California, the researcher examined the video portion, frame by frame, on his screen at the remote Massachusetts site. The resolution at each site is determined by the size of the pixels at the digitized site (maximum 72 dots per inch). The researcher at the remote sites examined the specified sequence field-by-field by controlling the server computer and selected a sequence for analysis.

After determining the portion of the performance for analysis, the researcher had to define the joints to be digitized. Specialized instructions were presented for defining the specific joints, such as the foot, ankle, knee, hip, as well as the golf club and ball. Following several other steps for naming and labeling files, the actual digitization began. As each of the selected points were digitized, the x,y coordinates for that point were determined immediately and were stored on the server computer in the appropriate file. The digitized points, in concert with the Common Gateway Interface (CGI), created a matrix of x,y, coordinates for further analysis. If only the two-dimensional analysis (2D) had been desired, the analytic portion would have been performed at this point. Since 2 cameras had been used to record the event, it was possible to obtain the preferred three-dimensional (3D) analysis. Therefore, the digitization process was repeated for



the second camera view.

Following the digitization procedures, the researcher had to establish an interface to the server using a commercially available program, namely, the HTML version 3 of Netscape. For this study, an ISDN telephone line was used with a transmission speed of 128K bits per second. This type of communication line normally requires less than 2 seconds to download each image. Since not all digitizing sites would have ISDN capabilities, the same sequence was tested using a 28.8K modem. The transmission time required using the 28.8K bits per second modem was about 15 seconds per image. It was determined that the test sequence was a length which reasonably reflected a normal, acceptable time allocation for biomechanical researchers.

After establishing the interface with the server, the researcher at California transmitted each of the digitized view files from the server (Site B) to his own computer at Site A using the File Transfer Protocol (FTP) Internet function. The files were reconstructed at Site A to determine if the data had been transmitted accurately. The data was confirmed to be identical to the duplicate set which was stored at Site B.

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

1. Analog video data is captured off-site and off-line through the use of a frame-by-frame advance VCR.
2. Analog video data is converted off-site and off-line to digital video data in AVI format.
3. 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.
4. The web server, through CGI, super-imposes the x,y,z coordinates on the video images.
5. 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.
6. The results demonstrated the use of the Internet to digitize kinematic data collected and maintained at one geographic location while the researcher was located at a second site.

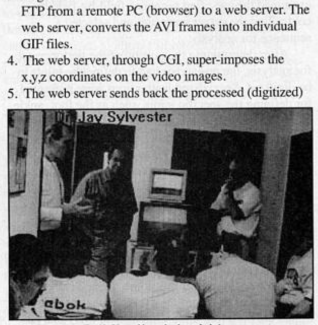



Fig. 10. Discus biomechanic analysis team:
Dr. Jay Sylvester, Dr. Gideon Ariel, and Dr. Al Finch

**Figure10. Presentation to the Coaches and Athletes. San Diego November 1996.**

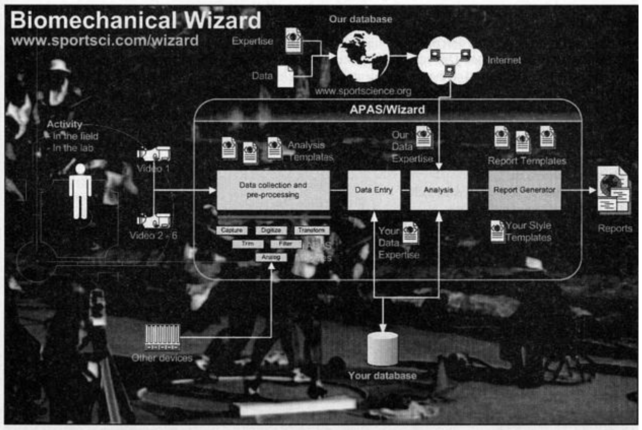
Efforts continue at laboratories around the world for biomechanical analyses of the other events. As soon as the work is completed, the results will be shared with the athletes and coaches to assist in their continuing efforts to improve. Mr. George Dales and the International Track and Field Coaches Association are committed to working with all athletes in every country with the free flow of information and, to that end, establish a library of all video data for all events.

## The Biomechanical Wizard

The previous information described the progress in the area of Biomechanical research performed in all Olympics Games from 1968 to 2000. However, the most dramatic improvement was utilized in the Athens 2004 Olympics. One could ask the question what consists an ideal biomechanical system. A "dream" system should have the ability to:

1. have miniature cameras able to transmit video data wireless to a central computer
2. utilize the Internet to send data to process centers around the world at high speed
3. monitor and see through the data collection camera the area of interest as a web camera
4. control the tripod remotely wirelessly from any location around the World
5. control the camera wirelessly from remote locations
6. collect video to be transmitted to multiple locations for immediate analysis
7. utilize the athlete's body as the control frame to determine volume coordinates
8. utilize body modeling to digitize the body's joint centers automatically
9. automatically report requested information by coaches and athletes
10. report generation of the results.

All these points were accomplished in the Athens 2004 Olympic Games. A description of the Shot Put analysis held at Ancient Olympia is described in a following article.




**Some Advantages of Adding APAS/Wizard to the Set of Tools:**

1. **Correctness** - the biomechanical, mathematical and statistical models used in APAS/Wizard guarantee that you will get the facts.
2. **Flexibility** - Everything in APAS/Wizard is determined by templates. You are welcome to use the default templates, or to modify them or create your own. The following standard "templates" are included:
   - **Protocol definition templates** define which types of analyses you can do. Default templates are supplied for specific sports activities, gait analysis, etc. They can be used "as is", or they can be modified or one can create his own.
   - **Report templates** define how the results of your analysis will be reported.
3. **Data exploration** - all collected data can be explored interactively. This includes
   - **Charting** of any kinematic variable of interest such as displacement, velocity, acceleration
   - **Rendering** of the 3D model to the screen.
4. **Online Comparisons** - all data collected can be compared to other data, or compared to the online database, for example,
   - compare your golf swing to Tiger Woods in charts, reports, numbers, or 3D.
   - compare your patient's wrist joint angles to the normative database...
5. **Tutorials** - documentation and tutorials on what to do in which step of the process are integrated into the system. The documentation includes
   - text
   - pictures
   - videos
   - 3D models

   One can substitute all or part of the default documentation with your own.
6. **Data Separation** - the following information is defined in templates and can be independently updated.
   - Protocol templates describe which questions will be asked. There are many different types of questions that can be defined.
   - Report content templates describe the contents of the report, e.g. which details (answers to the questions) should be analyzed and how they should be

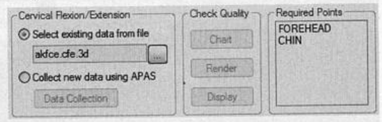


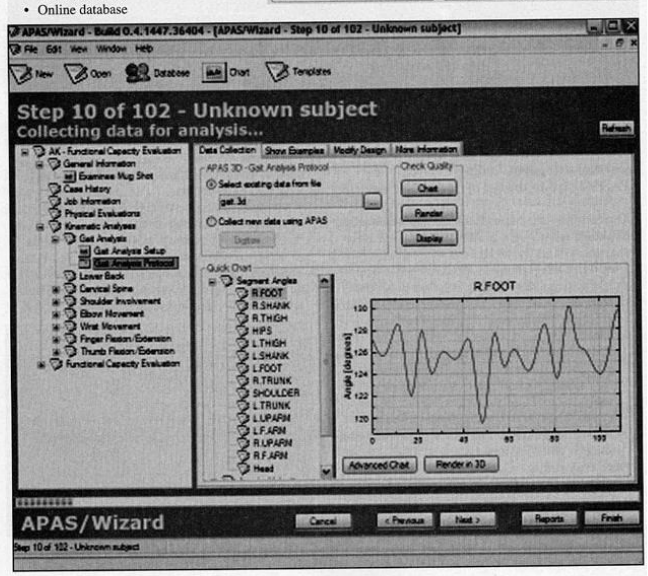
presented in the report (as tables, statements, or charts).
   - Report format templates describe how the report contents will be formatted. One can create detailed or summary reports based on the same contents, or have the report formatted specifically for a PDA.
   - Report style templates describe the fonts, colors, and other visual elements. This will make it easy to match the house style.
7. **Default Templates** are provided for sports analysis, gait analysis, etc ...
8. **Online updates** - stay up to date with the latest and report definitions

The database window allows you to explore different data sets:
- Local database
- Online database

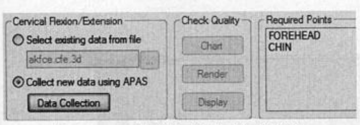
**Data Collection**

When APAS/Wizard is looking for **3D kinematic data** it will present a question such as presented below. You will have the option to select pre-existing data (notice the default file name that is already



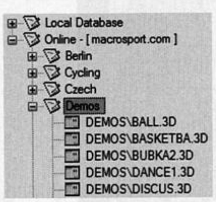
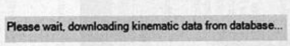
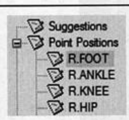
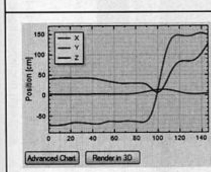



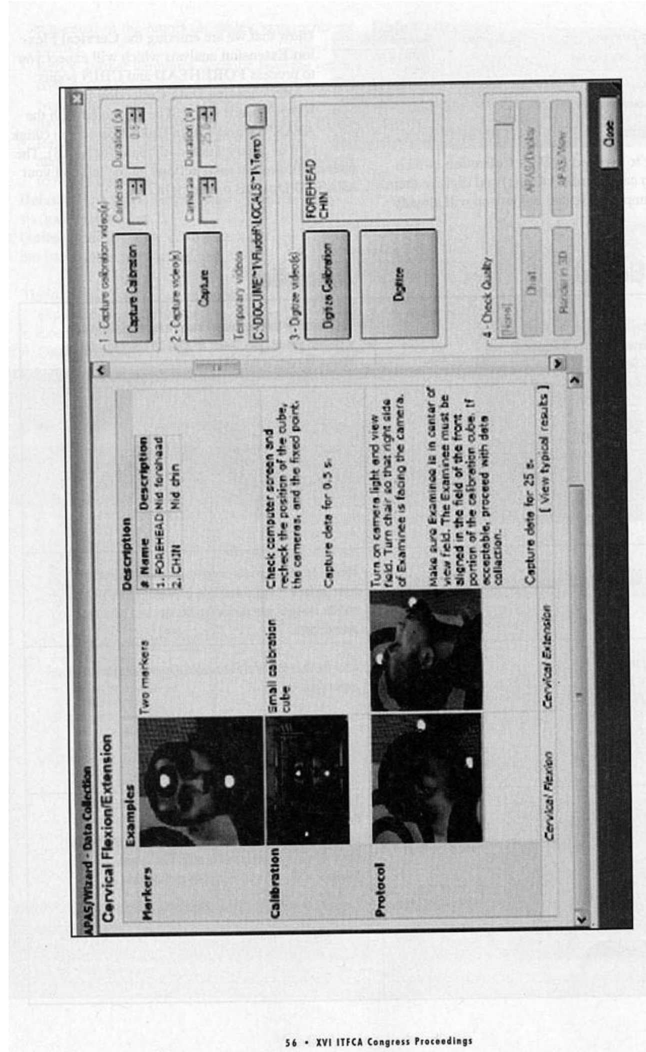



presented) or to proceed to **Data Collection** (which uses APAS to capture new video(s) and digitize them). From the example presented below you will already know that we are entering the **Cervical Flexion/Extension** analysis which will expect you to process **FOREHEAD** and **CHIN** points.

After choosing **Data Collection** in APAS/Wizard you will be presented with the **APAS/Wizard - Data Collection** screen (think of it as a navigation dashboard for APAS). The screen will present **instructions** on the left and your **APAS 3D Options** on the right:

| Screen Element | Description |
|---|---|
|   | **The navigation tree (left pane) shows a list of available data organized per category. Select an APAS 3D kinematics file to preview the data in the right pane.** |
|   | **When a data file has been selected, it will be downloaded from the local or online database. Depending on the location and the speed of your connection this may take a few seconds or more.** |
|   | **After the data has been downloaded it is available for further exploration.** |
|   | **The data can be previewed in the Quick Chart pane, or for further analysis you may choose:**<br>**Advanced Chart - where there are more options available and where data may be compared to other files as well.**<br>**Renderer in 3D - for a 3D visualization of this data.** |


APAS/Wizard - Data Collection
Cervical Flexion/Extension
Markers
Examples
Two markers
Description
# Name Description
1. FOREHEAD Mid forehead
2. CHIN Mid chin
Calibration
Small calibration cube
Check computer screen and recheck the position of the cube, the cameras, and the fixed point.
Capture data for 0.5 s.
Protocol
Turn on camera light and view field. Turn chair so that right side of Examinee is facing the camera.
Make sure Examinee is in center of view field. The Examinee must be aligned in the field of the front portion of the calibration cube. If acceptable, proceed with data collection.
Capture data for 25 s.
[ View typical results ]
Cervical Flexion
Cervical Extension
1 - Capture calibration video(s)
Capture Calibration
Cameras
Duration (s)
2 - Capture video(s)
Capture
Temporary videos
3 - Digitize video(s)
Digitize Calibration
Digitize
FOREHEAD
CHIN
4 - Check Quality
Chart
Render in 3D
APAS/Display
APAS/View
Close
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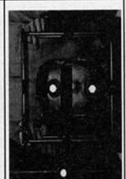
Relevant documentation for this protocol is shown in the left pane. It will tell you which markers are needed and where to put them. It will also show the analysis protocol or any other relevant information.

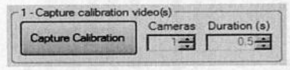
**Cervical Flexion/Extension.** Note: you are welcome to change the documentation.

| | Examples | | Description |
|---|---|---|---|
| **Markers** |  | **Two markers** | **# Name Description**<br>**1.FOREHEAD Mid forehead**<br>**2.CHIN Mid chin** |
| **Calibration** |  | **Small calibration cube** | **Check computer screen and recheck the position of the cube, the cameras, and the fixed point.**<br>**Capture data for 0.5 s.** |
| **Protocol** | <br>**Cervical Flexion** | <br>**Cervical Extension** | **Turn on camera light and view field. Turn chair so that right side of Examinee is facing the camera.**<br>**Make sure Examinee is in center of view field. The Examinee must be aligned in the field of the front portion of the calibration cube. If acceptable, proceed with data collection.**<br>**Capture data for 25 s.** |

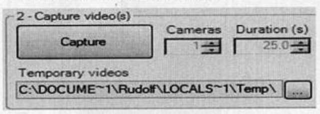


The following options are available for Data Collection:

**1 - Capture calibration video(s)** allows you to capture video(s) required for calibration. The number of cameras and the duration are preset for you (as determined in the protocol), so all you have to do is select **Capture Calibration** to capture the videos using APAS/CAPDV.

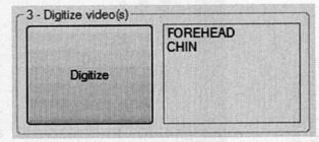



**2 - Capture video(s)** allows you to capture video(s) for the analysis. The number of cameras and the duration are preset for you (as determined in the protocol), so all you have to do is select **Capture** to capture the videos using APAS/CAPDV. Note that you can switch steps 1 and 2 if you prefer, redo either step if the results are unsatisfactory, or skip a step if you had already done it previously.



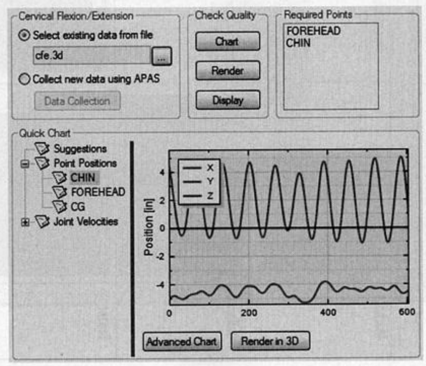

**3 - Digitize video(s)** allows you to use APAS/DIGI to go through the digitization process. Select **Digitize Calibration** to digitize the calibration videos, and select **Digitize** to process the actually activity. The points that need to be processed for the protocol (in this example FOREHEAD and CHIN) are shown on the screen before starting so you know what to expect.

The final result of these four steps will be an APAS 3D file containing the kinematic information for the points specified in the protocol.




**4 - Check Quality** will allow you to check the quality of the final APAS 3D file. Use any of the available options to judge if the quality of the data is acceptable. If not, you can redo any of the steps 1 - 3.

When happy with the results, you can close this window. The final results will be passed back to the main APAS/Wizard screen automatically - which you will notice in the Quick Chart.



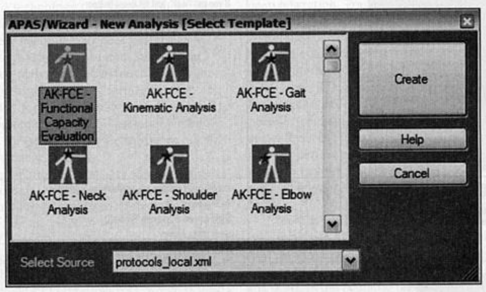



**APAS/Wizard - New Analysis**

A new analysis will always be based on a template (protocol). The template will determine which type of analysis will be done and which reports may be generated at the end of an analysis. There are many different types of templates available:

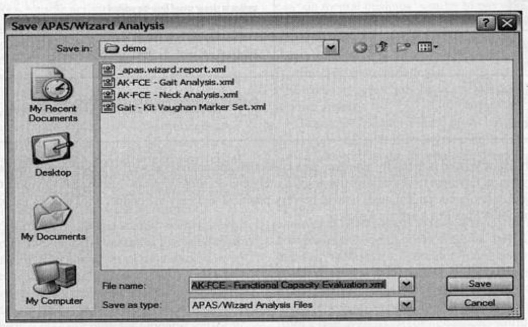
- Functional Capacity Evaluation
- Gait Analysis
- Sports Analysis

You may use the standard templates as provided with APAS/Wizard, or you can create your own.



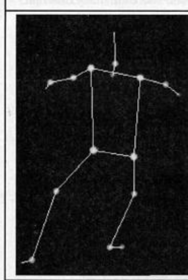
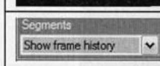
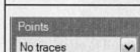
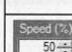
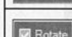

After selecting a template, your analysis must be saved first. This will allow APAS/Wizard to establish a working directory. It is revcommended:

- to accept the default file name **AK-FCE - Functional Capacity Evaluation**.
- to save the file in the **same folder** as your data files (if you already have any).




After saving your analysis you will end up in the APAS/Wizard screen.



| **APAS/Wizard - Renderer**<br>**Screen Element** | **Description** |
|---|---|
|  | **Any APAS 3D Kinematic file can be previewed in 3D. Use the following to navigate the scene:**<br>**Left Mouse - Rotation ("Turning")**<br>**Right Mouse - Translation in XY-plane ("Moving")**<br>**Middle Mouse Button - Translation on Z-axis ("Zooming")**<br>**If you get "lost", just hit Reset button.** |
|  Segments: Show frame history | **The following options are available for Segments:**<br>**No segments**<br>**Show current frame only (default)**<br>**Show frame history**<br>**Show all frames** |
|  Points: No traces | **The following options are available for Points:**<br>**No traces**<br>**Show trace history**<br>**Show all traces** |
|  Speed (%): 50 | **Speed as a percentage of the original speed. It is usually nicer to watch a motion in slower speed than the original.** |
|  Rotate | **Rotate will auto-rotate the activity around the Y-axis.** |
|  View: Reset | **Use Reset to reset the view to its original setting.** |

The ability of Wizard is to totally automate data collection and analysis as well as reporting the results. This tool allowed us in Olympia to get information immediately and accurately. Data collection in Olympia Greece proved that future biomechanical analysis will be very practical and easy to conduct with today's technology. (See Athens 2004 Shot Put Analysis Article.)