BIOMECHANICAL ANALYSIS OF SPORTS AND TRAINING IN LOCAL AND GLOBAL MICROCOSM. A Biomechanical Step Onto the Internet.

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INTRODUCTION

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 themselves 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, 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.

METHOD

The purpose of the present study was to test 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.

Golfers were filmed during a local club competition. All golfers performed the same golf drive which was selected for the test sequence. Two cameras were placed at approximately 45 degrees to the plane of the path of the golf swing and were camouflaged in a manner which would not distract the competitors. Following data acquisition of all the participants, one swing for each of two of the contestants was selected for further analysis.

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 A while the digitizing computer, Site B, resided at a distance of approximately 1500 km. The first step was determination which the specific portion of the golfers' swing was to be selected for subsequent analysis. Although the actual digital data was stored on the computer located at Site A, the researcher examined the video portion, frame by frame, on his screen at the remote site, Site B. 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 Site B 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 the 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.

RESULTS

After establishing the interface with the server, the researcher at Site A 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.
(4) The web server, converts the AVI frames into individual GIF files.
(5) The web server, through CGI, super-imposes the x,y,z coordinates on the video images.
(6) 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.

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.

DISCUSSION

The study successfully demonstrated that digitization is a biomechanical task which can be performed between different geographical locations using the Internet as the interfacing medium. The applications of this technique and intellectual resource appear unlimited.

For example, a golf teacher in New York can video his students' swings. These video clips can be transmitted digitally in AVI format to a server in one part of the world and then interfaced to the biomechanical program for further analysis. Many Olympic events make fixed laboratory studies difficult, including equine events, sailing, and cross-country skiing. Coaches can film actual performances on site using cameras with direct AVI format input attached to Laptop computers. These files can then be digitized or transmitted through Internet protocols.

Biomechanical quantification has developed far beyond the pioneers who relied upon visual observations of animation to describe movement. The revolution continued with improvements in cameras, the introduction of computers, development of various algorithms to better fit the data, and expansion beyond sports studies. Additional innovations in the process are expected as the Internet further evolves into newer presentation technologies involving animation and virtual reality (e.g. Java and VRML).

The ability to quantify motion has appeal to many groups and at many different levels. Access to global resources via the Internet expands biomechanics beyond a fixed geographical location. This has direct applications in medical research and industrial engineering where, frequently, transmission and processing of research data between remote sites has to occur in a real-time mode.

Thus, the subject presented and studied in this document represents a significant threshold in furthering the accessibility and applicability of Biomechanics to several scientific, medical, industrial and aeronautical endeavors far beyond its present reach.