INTUITIVE AND INTERACTIVE BIOMECHANICAL ANALYSIS OF SPORT SKILLS

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INTRODUCTION

Historically, sport biomechanic laboratories have combined research-based commercial software with in-house programming to meet their requirements. Non-laboratory-based independent researchers, teachers, coaches and students have had limited access to suitable and affordable computer-based tools for general movement and sport skill analysis. Recent developments in multi-media computing, frame grabbing, and video technology have combined to make powerful desktop computer software feasible, and the result has been a proliferation of research-based and often hardware-dependent computer tools which still leave a majority of teachers, students, coaches and independent sport skill analysts with limited resources. On the other hand, it appears that computer software programs, over time, tend to migrate toward a common-look, efficient, intuitive product such ad found in word processing, spreadsheet and database management. A sharing of computer analysis approaches in sport biomechanics will undoubtedly lead to improvements in available software which, in turn, will have a positive impact on research, teaching, and learning.

METHODS

The object, then, was to determine the fundamental components for a general, portable, two dimensional sport biomechanic computer analysis program, develop the computer program and then assess its success in selected applications. Specifically, the program would be used for structured introductory laboratories with a large class and for original student projects in a smaller advanced class. The original projects would simulate potential use and application by coaches, teachers and non-laboratory-based independent researchers.

BASIC FRAMEWORK

A basic framework for the analysis program was established and included:

1. a PC-Windows-based intuitive, interactive environment
2. a teaching-learning focus
3. hardware independency

A PC-Windows-based platform was selected to ensure the program would be accessible across the largest possible constituency. A teaching-learning focus for the program was important since, although it is intended to complement and supplement but not replace course and independent study in biomechanics, it would need to be self instructive if it was to be useful for the intended audience. The requirement for hardware independency becomes critical, if the program was to achieve true portability. To meet this objective an Audio Video Integrated or AVI format was selected for the source video files. Most commercial frame grabbing boards provide this option for capture format.

PROGRAM COMPONENTS

The next step was to identify and categorize the elements integral to video-based biomechanical analysis, that would form the structure for a general purpose computer program.

1. Establishment of trial parameters
   a) collection point identification
   b) segment definition with related standardized data
   c) segment system identification
   d) relative and absolute angle definition
   e) viewing model description
   f) trial defined critical points
2. Digitizing of defined point collection with related processing
   a) linear scaling
   b) aspect ratio
   c) tilt correction
   d) panning correction
   e) movement direction reversal
   f) frame by frame, point over frame digitizing
3. Data enhancement or smoothing

4. Calculation of kinetic variables
    a) absolute angles
    b) relative angles
    c) segment centers of gravity
    d) system centers of gravity
    e) velocity
    f) acceleration
    g) segment kinetic energy
    h) system kinetic energy
    i) segment momentum
    j) system momentum
    k) segment moments and forces
    1) system support forces
5. Post calculation processing
    a) data enhancement or smoothing
    b) presentation template (scale, decimals, units)
    c) normalizing to relevant base
    d) digitized coordinate pair correction
    e) angle discontinuity corrections
    f) applied algebraic operations
6. Figure model display
7. Graphing data
    a) variable-time graphs
    b) variable-variable graphs
8. Hard copy options
    a) local text, figure model and graphic output
    b) exporting figure models, graphs and video frames

SUPPLEMENTARY PROGRAMMING GUIDELINES

In order to meet the intuitive, interactive environment and the teaching learning objectives as established in the Basic Framework it was necessary to establish a limited number of supplementary programming guidelines.

1. Default or pre-defined trial parameters

Each full digitizing and analysis session requires the identification of collection points, segment and system definition and other parameters introduced in the previous section as the Establishment of trial parameters. For first time or beginning users, these requirements can often be a distraction from the larger analysis objectives. Similarly,

it should be unnecessary for knowledgeable users to reconstruct the parameters for each analysis. Therefore an intuitive and interactive computer program must provide for default or pre-defined trial parameters.

2. Execution of pre-constructed macros

As with the development of default and pre-defined trial parameters, it is often unnecessary for first time or beginning users to know the details and conventions for calculating displacements, velocities, accelerations, energy, etc., even though they may understand and interpret such data. Likewise, knowledgeable users may have the need to do repetitive analyses for a number of subjects or trials. In this case an intuitive and interactive computer program must provide a system for the execution of pre-constructed macros.

3. Visual presentation of analysis procedures and results

A major requirement of intuitive and interactive analysis is to provide appropriate visual representation of the procedures and results. The range of visual components can include:

a) video frames
b) video frames with digitized figure models
c) variations of figure models displayed independently
d) graph displays of analysis results
e) run time coordination of video frames, figure models and graphs
f) simultaneous display of results for multiple subjects
g) results of data harmonic analysis and the effect of data smoothing

Major objectives of intuitive and interactive analysis include presenting an effective teaching learning experience for beginning and first time users, and for knowledgeable users, providing an efficient means to making initial and exploratory analyses.

RESULTS

The computer program was created and, in various stages of development, has been used by approximately 800 students over the past four years. In the current academic year the computer program formed the basis for both structured introductory laboratories and advanced individual projects for classes totalling more than 300 students. At least 100 students completed their laboratory assignments or individual analyses on "home" installations.

CONCLUSIONS

Contemporary multimedia computer technology has brought effective two-dimensional biomechanical analysis to the desktop. The main limiting factor is the availability and effectiveness of software tools, but it is inescapable that the teaching and learning in biomechanics will be influenced by these developments.

In the future, sport biomechanic software will migrate to a flexible but common presentation or "look" and, minimally, stand alone computer analysis programs will be available in CD form or from Internet sources. During this developmental phase, it is important for researchers and particularly teachers to share and make known the specific requirements fundamental to successful biomechanical analysis.