A LOW COST PACKAGE FOR THE ANALYSIS OF HUMAN BODY KINEMATICS

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At the end of the 19th century. Weber and Weber (1836) demonstrated that it was possible to quantify the movements of the Human Body through the application of the laws of the Classical Mechanics and confirmed the existing belief that it would be possible to obtain reliable information on those movements from experimentally acquired data.

The first experimental procedures utilized for the study of human movement were based on photogtaphic techniques with the pioneer work done by Marey (1882) who used photographic "gun" to record displacements in human locomotion movements and chronophotographic equipment to produced free-body diagrams of a running subject. Muybridge (1884) who used 24 aligned cameras which he triggered sequentially to record running patterns and Braune (1895) who developed the first three-dimensional recording set-up with chronophographic equipment. These three authors elaborated recording methods which were not adequate for easily repeated recording. As an example. Braune recorded walking movements by successively illuminating different parts of the body with nitrogen filled Geisseler tubes.

The technological progress of the recent decades has changed the situation drastically by introducing techniques such as goniometry, ultrasound recording, magnetometry. accelerometry, photography and film-and videocinematopraphy. which made possible the massive recording of most types of movements.

Each of these techniques has its advantages and limitations:

TECHNIQUE		ADVANTAGE	LIMITATIONS
Gonyometry	. .	Cheap and instant results	Slow procedure, intrusive
Accelerommetr y		Instant results	Expensive, intrusive
Ultrasound		Great precision in small areas	Unsuitable for large movements; Physical environment interferences
Magnetometry		Very efficient for small areas	Inappropriate for large spaces
Image	Cinematography	Good image quality; non-intrusive	Expensive; slow processing; exact illumination requirements
	Vídeo	Cheap; non-intrusive; quick feedback	Poorer image quality; slower frame rate.
Analysis	Still photography	Good image quality; non-intrusive	Expensive; slow feedback

The utilization of image analysis is, in our opinion, the most promising system for the study of sports movements. This approach implies the digitization of the co-ordinates of conveniently chosen markers locate on-the 'image frames and the posterior processing of these co-ordinates to extract the relevant kinematic information they convey.

This image processing may be performed manually or automatically. The best known automatic systems are the Peak Performance, the Elite Motion Analyser, the MacReflex Motion Analysis System and the Ariel Performance Analysis System(APAS). Although these systems are highly thought of by most motion analysis workers, they still suffer from a few limitations:

1. They are far too expensive for generalised utilization
2. They require extremely complex calibration procedures and, thus, they are not easily transportable to the training and competion grounds.
3. They do not perform fulley automatic 3D analysis of the more complex movements which occur in sports.

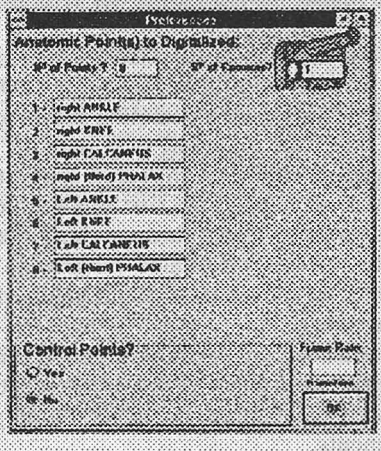

Fig. 1 - Specifications of the coordinates to digitized

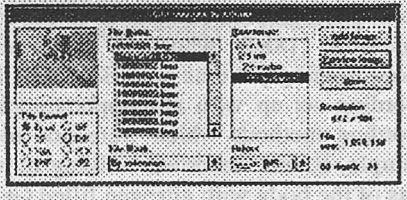

Fig. 2 -Chose of the first file of image

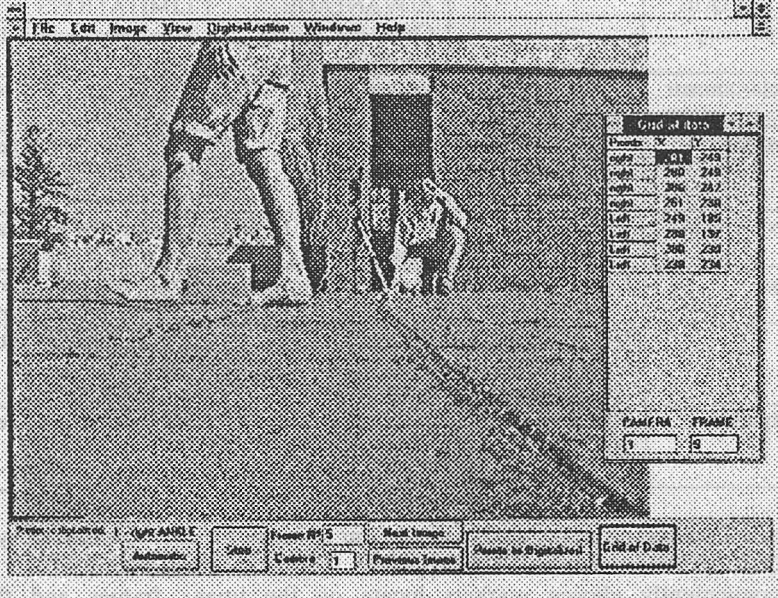

Fig 3 - Layout Digitalization

The manual systems which are marketed presently are based on cinematography and video and suffer from drawbacks such as high costs and a very slow feedback, for the first method, and poor image quality and definition for the second.

With these facts in the background and pressed by the need of solving our own problems of kinematic data acquisition and processing, we developed a low cost PC-based video image acquisition system. The video film is passed through a table video mixer which allows the visualization of successive well immobilised single pictures in order to select the relevant frames to be stored in the computer disc by a frame grabber. The frame grabber has a resolution of 800x600 pixel with for 24 bit colour pictures or a resolution of 1024x768 with for 8 bit colour pictures. These resolutions are considerably above those accessible in the PAL and NYSC video systems.

The software we have developed enables us to digitize, on the recorded images, the co-ordinates of relevant markers placed on the body segments as well as to perform certain image processing schemes such as image filtering, adjustment of contrast and brilliance, zooming and image conversion.

The software package uses all the facilities of the Windows™ System to simplify its utilization. Figure 1 corresponds to the first step in the process which consists in naming of the markers to be digitized in the image frames. In a second step, figure 2, one of the image files is chosen and is stored and displayed in an "album" on the left side of the screen. To call from the album an image to digitize we need simply to perform a double click on it. This action and the call for the menu "Digitalisation-Begin" brings in the Digitization Layout (figure 3). The digitization process is now carried out, each marker being dealt with in the same order they were listed in figure and in accordance with their names as displayed in the Layout under "Points to digitise". The processing of a marker is accompanied by the storing of the co-ordinates in a data matrix and, at the same time, the operator is automatically called to digitise the following element in the list. This process proceeds until the last marker is done.

When each frame has been processed, the system offers the possibility of moving on to the "Next Image" or to the "Previous Image" by the pressing of the corresponding buttons.

The data matrix which is being formed during the digitizing process can be displayed on the screen by pressing the "Grid of Data" button. At the end of the process, or at any other desired time, it possible to save the matrix of data to a DOS file formatted in such a way as to be read by any of the common program. The stored co-ordinates may be written in this file using either the original pixel co-ordinates or else converted to any convenient system of units.

The package is presently operational in its two-dimensional version and its extension to three-dimensional data processing is not yet finished but is already at a quite advanced stage.

REFERENCES

Braune (1895) The Human Gait. Springer-Verlag

Marey (1882) Analyse du mechanism de la locomotion au moyen dúne série dímages photographiques recueillies sur une même plaque et representant les phase sucessives du movement. Comptes redus, Vol 95. Naples. 14.

Weber W., Weber E. (1836) Mechanick der menschlichen Gehwerkzeuge. Gottingen