RECOGNITION OF HUMAN MOVEMENT PATTERNS

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INTRODUCTION

Since a few years ago computer science means an important support to biomechanical analysis. Whenever a lot of calculations are to be made, and the value of different parameters like mechanical variables are needed, the advantages of using computers are clear. However a bottleneck is present in data acquisition process for cinematic analysis from video sequence.

Traditionally this task is performed like a manual process: user of computer systems must mark, for each frame, some articular points (about 20-21) by means of an optical pencil or using a mouse on the computer display once image has been digitalized. This is a routinary task and takes a lot of time. For example, for three seconds of movement, we probably need to process about 150 frames and, for each of them, to perform a digitalizing process

Recently new approaches are used to allow an automatic recognition. These approaches are based on the use of body optical sensors. Recognition process is easier because we only see several single points in the screen (under special environment conditions). However, these approaches are no applicable in real situations (i.e. competitions) which are the most interesting moments for analysis.

What we propose here is an attempt to make an automatic system for data acquisition process from video sequences in sport environments and, as a general rule, for the analysis of human movement..

We must take into account that the complexity of recognition process is lowered if we are working into a very narrow domain, like cyclic movements with 2D analysis (i.e. path of legs in some kinds of running). Nevertheless, our approach can be transfered to movements with 3D analysis if tridimensional reconstruction from human shapes has been performed.

METHODS

The system we present here can be considered as a hibrid system in the area of Artificial Intelligence because it is built with Conexionist techniques (Artificial Neural Networks) as well as an Expert System besides an image digital processing.

The general objective of the project is to allow an automatic digitalizing of sport movements sequences corresponding to real situations (competitions). However, as the first step we try to reach the objetive with the following simplifications:

- The sport we are going to analize is running. The footage is 2D (we are not knowing the internal rotation of the hip which would force us to a 3D footage). In other hand we only analize the legs (the experts think that the legs are the most important part of the body to study the movement in runnig).

- Filming with special conditions: Brightness, clue objects (legs) remarked by means of using dark sportwear and image background in white colour. All this conditions will be a great help in first stage of the general process.

Biomechanical experts opinion is that a system functioning with this features would be useful.
An overview of the whole system appears in the following block diagram:

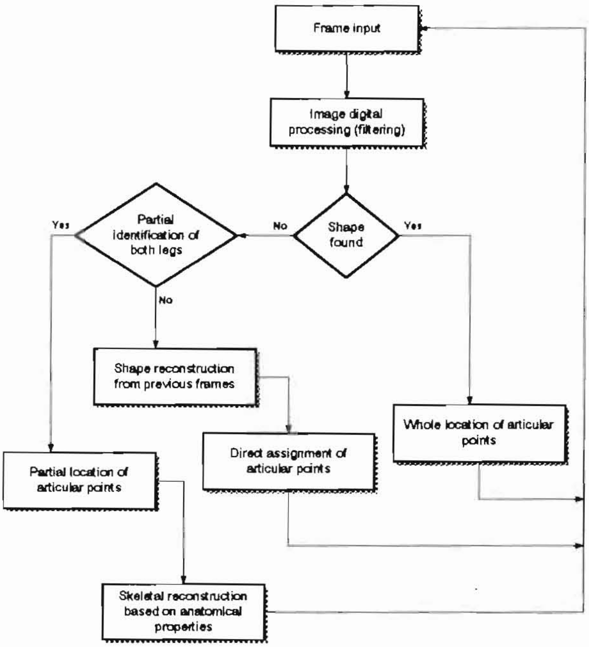

Figure 1: Block diagram of the whole system

The system can divide in two subsystems clearly separated: a stage devoted to try to found a shape representing, with a high grade of reliability, image perspective, and another stage devoted to locate, in the shape, the articular points necessary to movement analysis.
In the first stage the system performs filtering operations, edge detection and, optionally filling of interesting areas.
The results can be satisfactory (it is true in most frames filmed with special conditions) or not. A negative result can be a partial identification of one or both legs. Partial means that the shape is not completely separated and it has some of the following features:

- All the articular points excepting the knee can be located
- The system can locate all the articular points excepting one of the following: lateral malleolus and heel.

We can add other conditions (more general) but system reliability wouldn't be completely warranted.
In the case of a partial identification th system goes on with the location of the articular points corresponding to the areas in the shape that are clear (partial

location). Then, the location of the other articular points is calculated using the following techniques:

- Applying the condition of invariant (during all phases of movement) for the segments knee-hip, knee-malleolus and malleolus-heel.
- Taking into account an anatomical property: the rotation center for the hip, knee, and malleolus is situated in a middle position respect to the corresponding shape segment. This makes possible a projection on an adecuate direction using as lenght the values for any invariant segment mentioned bellow (s1 and s2 in the figure).

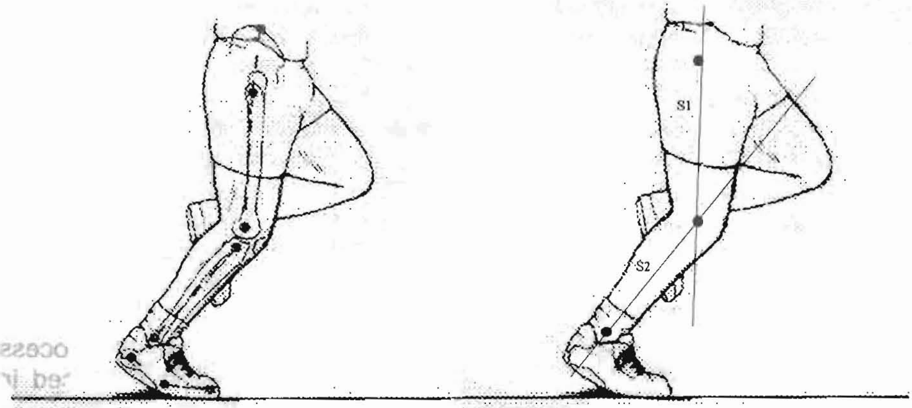

Figure 2: Anatomical features for location of some articular points.

- Using the simplification that in the phases in which hidden leg is almost invisible and those in which the system can not identify neither the knee and the hip, we can consider that the locations of the rotation center of the hip in both legs are superposed when the filming view is perpendicular to the movement.

In the case of neither a partial and total identification is possible (the restrictions are no present), it will be necessary a shape reconstruction from previous frames in which the complete location of articular points has been performed. To carry out this task an Artificial Neural Network has been developed. ANN type is Hopfield (clasifying).

This ANN perform a matching between the shape of any previous frame and present frame. Because we are analizing a cyclic movement the result of the ANN will be adecuated.

If the shape can be completely separated the system performs a location of articular points for all the areas.

In order to make possible the location task both total and partial we have designed an Expert System for Digitalizing. Knowledge base for this expert system include: anatomical knowledge, antrophometrical knowledge, cinematic knowledge and expert knowledge.

Anatomical knowledge has been codified with information such:

- Placement of articular points in relation with a longitudinal symmetrical axis in the shape and taking into account movement direction.

- Placement for some articular points relative to the edge of shape.

Antrophometrical knowledge includes the lengths of the invariant articular segments as well as its location on the shape.

Cinematic knowledge gives to the system information about movement paths for articular points as well as the values for angular distances between segments. All this knowledge is destinated to confirm the location of articular points.

Expert knowledge come from several individual methods used by persons devoted to manual digitalize process. Some of this methods are:

- Rotation center for the hip: Location by detection of greater trochanter relief in the shape, by middle placement in the thigh taking as vertical reference a middle position of the gluteal region or by projection from rotation center of the knee towards middle position mentioned above with the lenth equal to the corresponding stored value for the articular segment.
- Rotation center for the knee (the variability of the location depending on the phase of running is ignored): Location in the center of an imaginary circunference tangent with external edge of the knee shape.
- Lateral malleolus: 0,5 cm. above from sport shoe upper edge in a middle position of the shape or by detection of malleolus relief.
- Heel: 0,2 cm from upper and back edge of the sport shoe.
- Foot extreme: 0,2 cm. from shape extreme.

All process is performed to each frame. If the frame is the first the process is manual and invariant values for some articular segments are introduced in a antrophometrical database which will be used by the expert system.

RESULTS

With footage in special conditions (brightness, remarked objects and white image background, the differences between system proposed here and a manual digitalization is zero-two units.

By means of refinement of expert system knowledge base and a different way to process the input frame we hope to get simlar results with no special filming conditions.

CONCLUSION

The system we propose can help to biomechanics to reduce a lot the time destinated to perform data acquisition. Several hours would be changed to some minutes without human assist.

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