VIDEO ANALYSIS OF JUDO SITUATIONS TO LEARN PHYSICS

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Abstract

Sport offers many opportunities to evidence how physics can construct models of real-life phenomena. In this work we present a video analysis and modeling of *judo throw techniques,* which could be the basis for a teaching and learning proposal of physics in the context of judo. We perform a video analysis of motion of the athlete that is thrown on the tatami: we measure the kinematical quantities of selected points; we model the observed motion with simple rigid body models; we deduce the dynamical conditions which produced the observed motion.

1. Introduction

The context of sport offers many opportunities to evidence how physics can construct models (Bednar et al 1991; Hesteness 1992; Michelini et al 2002;) analyzing complex and not controlled phenomena (Bradamante et al 2004) and to evidence the differences with the biomechanics and engineering models. A proposal for physics in the context of judo was designed, based on video analysis and modeling of judo throw techniques. In this work we present the video-analysis procedure which delineates the strategy that could be adopted in school laboratory. The procedure is constituted by two steps: video-analysis of the kinematical quantities describing the motion of the athlete thrown on the tatami; construction of simple rigid body models that explain the observed motion. Three main aspects are analyzed:

- the force couple acting on the opponent who undergoes the technique (in judo called Uke-U), which is produced by the other contestant (Tori-T);
- the centers of mass relative positions of the two contestants and the trajectory of Uke;
- the dynamical condition that explains the observed motion, using simple models as point-like and rigid body models.

2. Judo throwing technique and which elements to look at

In a judo throwing technique, Uke (U) and Tori (T) are always interacting physically in contact. We can analyze the motion of U to recognize the resulting forces acting on him.

We start from video analyzing the motion of one or two points selected from the points indicated in biomechanics literature (Sacripanti 1996, Blaise et al 2002).

3. Application of a force momentum to rotate a body in a judo throwing technique

In figure 2 a sequence of a Seoi-nage technique is reported. First of all we perform a qualitative analysis, recognizing four discontinuities: A) the beginning of the action; B) stop and rotation of Tori; C) Tori loads Uke on the back; D) Uke falls down on the tatami.

The discontinuities define four main phases: *Phase F1* - From A to B: The motion of U (top-left photo in figure 2) is approximately uniform; *Phase F2* - From B to C: U is accelerated in a circular motion with center being his right foot touching the tatami (top-right photo in figure 2); *Phase F3* – From C to D: U is accelerated in a circular motion around a barycentric horizontal axis (bottom-left photo in figure 2); *Phase F4* – From D to E: U falls down on the tatami following an approximately vertical line (bottom-right photo in figure 1).

Figure 1: The different phases of a seoi-nage technique are illustrated (pictures selected from a video).

The motion of U is due to: the interaction between T and U in F2 and F3; the interaction between U and the earth in the F4. The trajectories of the hip and of the shoulder of U are represented in figure 2. The analysis was made using tools available in common photo editors. The trajectory is reconstructed step by step, using a fixed reference system.

Figure 2. Trajectories of the hip and of the shoulder of U

For this reason we can analyze the video obtained from a moving camera. This method is generally not used because it is time consuming thus inefficient, but it offers the following advantages:

- The use of paint/photo editors available in all computers (cheap, no need of instruction);
- It is possible to follow "hidden points" during the motion (when the body turns);
- No need of a fixed camera – need only of a fixed reference as walls or fixed objects;
- Opportunity to realize personal re-elaborations as very expressive power point presentation.

A quantitative analysis of the motion can also be performed. From the position on the screen of the selected points, knowing the time between a frame and the following (0.04 s), using a simple proportion between screen points and real linear distances, we are able to obtain the velocities of the selected points along the x and the y axes, individuating the plane of the video. In figure 3 are reported the linear velocity of the hip and the angular velocity of the shoulder around the center of mass c axes of rotation.

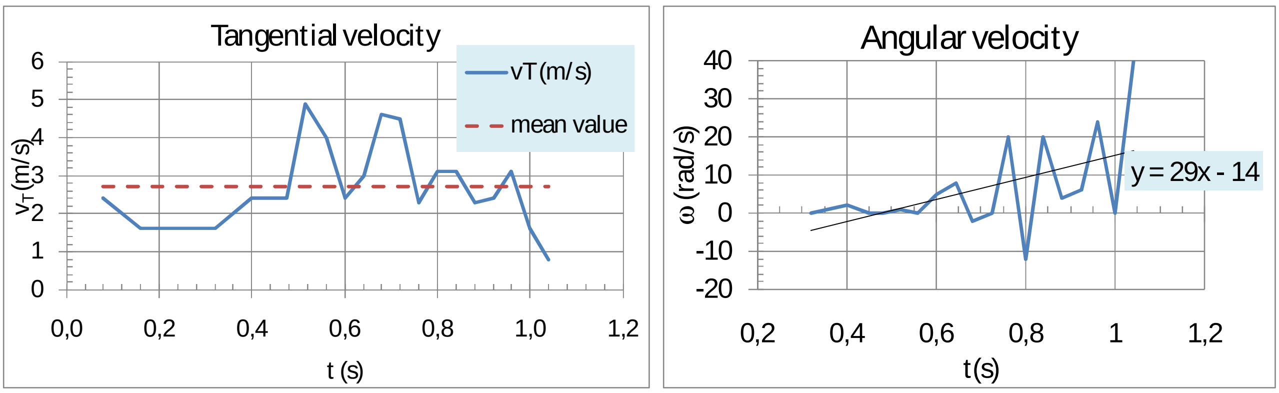

Figure 3. Time evolution of the linear velocity of the hip and of the angular velocity of the shoulder.

A dynamical analysis of the motion can be made from the results represented in figure 3. From 0 to 0.68 s, in F2, <Vy>= 0 m/s and therefore the hip remains at the same level. We conclude that the hip rotates around a roughly barycentric horizontal axis. The x and y components of the resultant of forces applied on U by T in F3 are different from zero. A force momentum acts on U. If we

describe U as a unique rigid body, because the angular velocity linearly increases, the torque acting on the U-rigid body is constant. This constant torque produces an efficient energy transfer only when a resonant condition is reached in the movement of T and U.
This aspect is particularly evident in the technique named okuri-ashi-barai, represented in figure 4, where the trajectories of the hip and of a point close to the centre of mass of U are shown. In the right side of figure 5 the coupling of the two contestants is analogically illustrated by the coupling of two oscillators in phase, modeling the energy transfer.

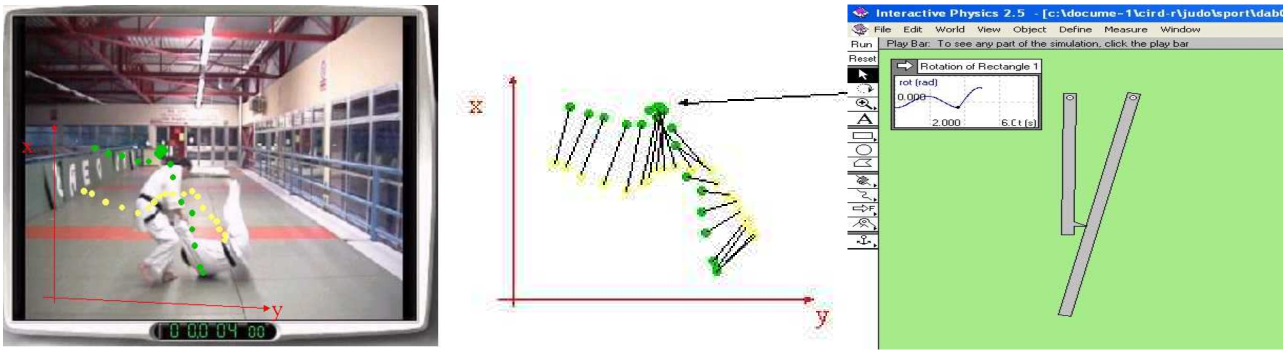

Figure 4 Analysis of the motion in the okuri-ashi-barai technique, by modeling it with two a rigid pendulum and simulating the energy transfer in Interactive Physics environment.

4. Conclusions

A video analysis of the motion of a judoka that undergoes judo throwing techniques was performed. We use commercial and very common picture/photo editors to follow the motion of selected points of the athlete. We carried out a qualitative and quantitative analysis of the motion. By modeling the human body with a rigid body, we are able to delineate a very simple dynamical analysis of the motion. The procedure used does not require specific software. It can be very useful to realize explicative presentations and can be the basis for developing educational activities in which mechanics and dynamics can be proposed in context.

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