Physics of Karate. Kinematics analysis of karate techniques by a digital movie camera

Concetto Gianino
Liceo Scientifico Statale "E. Fermi" di Ragusa, Viale Europa, 97100 Ragusa, Italy.

E-mail: concetto.gianino@istruzione.it

(Received 16 November 2009; accepted 13 January 2010)

Abstract

In this paper it is shown the kinematics and dynamics analysis of karate techniques by a digital movie camera. This method is very easy to use with student of High School and it allows them to improve their physical insight and problem solving skills, helps them to understand the difference between the theoretical model and the real system.

Keywords: Physics Education, Classical Mechanics teaching, Art Martial, Karate, Digital Movie Camera.

Resumen

En este artículo se muestra la cinemática y dinámica del análisis de las técnicas de karate mediante una cámara de cine digital. Este método es muy fácil de usar con los estudiantes preuniversitarios, y les permite mejorar su visión física y destrezas para resolver problemas, les ayuda a comprender la diferencia entre el modelo teórico y el sistema real.

Palabras clave: Educación en Física, Enseñanza de la Mecánica Clásica, Arte Marcial, Karate, Cámara digital.

PACS: 01.80.+b **ISSN 1870-9095**

I. INTRODUCTION

The analysis shown in this article has been carried out for a didactic project, in the school year 2007/'08, focusing on the study of Physics laws applied to Karate that has involved about 30 "Q. Cataudella" High School students[1] with the collaboration of Karate Instructor Antonino Giannì (black belt 3° dan) and Technical Assistant Angelo Budello. This project gets in 2009 the certification of quality European STELLA (Science Teaching in a Lifelong Learning Approach) and it is selected between the best four Italian learning science practices for eBook "Science Education in European Schools - Selected Practices from the STELLA Catalogue"[2]. In the specific case, a digital video has recorded the Karate techniques of the Instructor, subsequently analyzing the single frames the trajectories and the motion diagrams have been reconstructed, from which it has been possible to deduce the kinematics characteristics such as the general duration of the technique, the average acceleration and the striking velocity.

II. KARATE, PHYSICS AND TEACHING

Karate means literally "empty handed". It was born on Okinawa island thanks to Kung Fu (Wu Shu) Shaolin Chinese Monks' influence. It was developed in the early 17th century when the Japanese occupied the island and banned the use of all weapons and sorts of fight. In the 20th century, thanks to Gichin Funakoshi, Karate will be acknowledged as a National Japanese martial discipline. It started to acquire the laws of Philosophy Zen and also the word Karate-Do, whose complete meaning is: "The way of knowing yourself by practising Karate" [3].

By these Physics investigations of Karate techniques we found out that they have been incredibly well planned and turn into accurate physical optimizations of human movements [4, 5, 6, 7]. Scientific analysis together with the practical application of the Karate techniques can also be an efficacious resource for teaching Newtonian mechanics, because it is highly motivational for students [1, 7, 8].

The Physical analysis of human body movement is not simple since a human is a complex apparatus, but if all of our parts work in harmony it will be possible to create a simple theoretical model that allows to describe the movement with good approximation.

One of the educational goals has been the analysis kinematics of some Karate techniques by a digital movie camera. The modest setup is made up of a digital movie camera connected to a computer with a common video acquisition and analysis software.

We have recorded Instructor video while he was performing the techniques with parallel movements to the area of the movie camera zoom lent. The analyzed karate techniques have been carried out, in the following order

- Gyako-tsuki: opposite punch
- Oi-tsuki: stepping punch

- Mae-geri: front kick
- Yoko-geri keage: side thrust kick
- Yoko-geri kekomi: side snap kick

III. KINEMATICS ANALYSIS

A digital movie camera has recorded everything with a frequency of 25 frames a second and therefore the frames followed each other every 0,04 s. Analyzing the succession of the frames we have reconstructed the trajectories (Fig. 1).

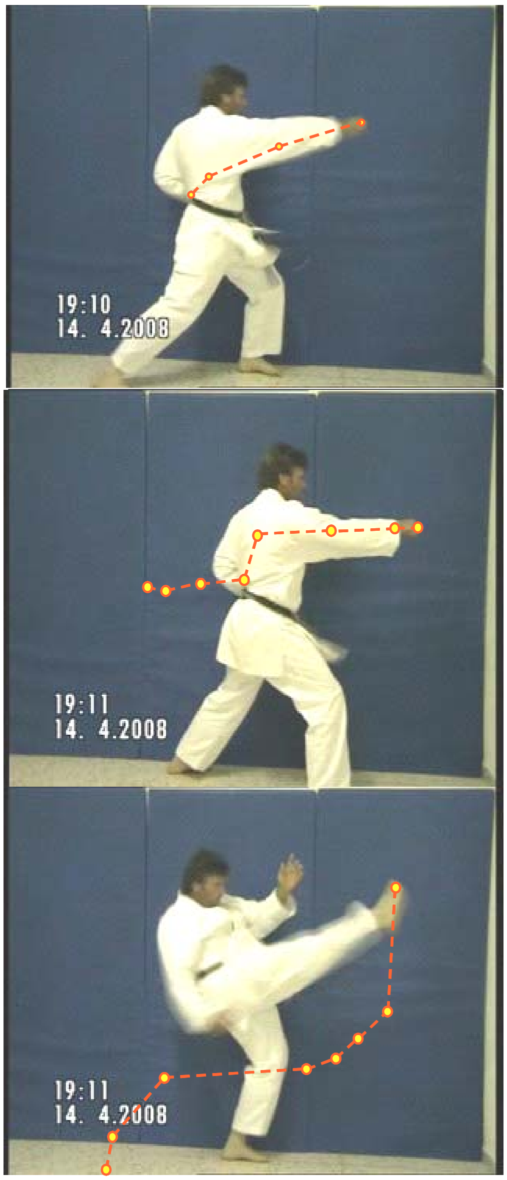

FIGURE 1. From up to down, an example of trajectories of fists Gyako-tsuki, Oi-tsuki and of the kick Mae-geri developed with the frames analysis.

Besides, measuring fist and foot displacements we have reproduced the motion diagrams of the five techniques and we have valued the velocity and acceleration taken from the total displacement in x and y. As it is clearly shown in fig.2, in Gyako-tsuki technique the fist projections can be schematized, with good approximation, with a uniformly accelerated motion (red line) with the acceleration of about 63 m/s^2, reaching a final velocity of about 13 m/s.

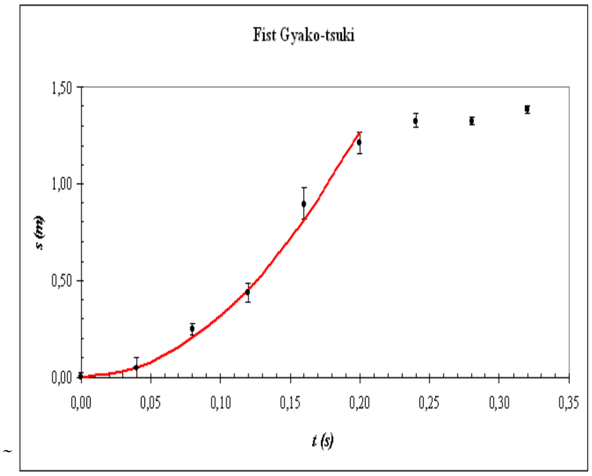

FIGURE 2. Motion diagrams of fist gyako-tsuki. Curve of the best fit (red line) of the experimental points, calculated by software CassyLab. The curve equation is due to the accelerated motion.

Instead, the motion diagrams of the other techniques are more articulated:

- Mae-geri, (Fig. 3) it seems that initially the foot is moved with a uniformly accelerated motions (rotation of the hip) with a acceleration of about 108 m/s^2 and later (lower leg movement) with a acceleration of about 78 m/s^2, reaching a final velocity of about 19 m/s.
-

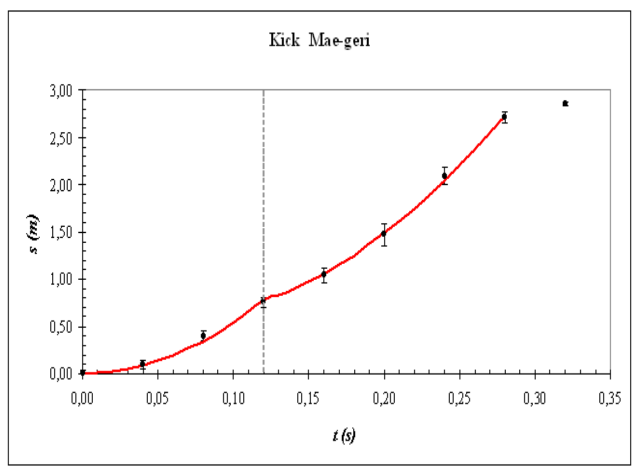

FIGURE 3. Motion diagram of kick mae-geri. Curve of the best fit (red line) of the experimental points, calculated by software CassyLab. The curve equation is due a sequential combination of two uniformly accelerated motions.

- Oi-Tsuki (Fig. 4), it seems a sequential combination of three motions: first (fast rotation of the hip) a uniformly accelerated motion by acceleration of about 18 m/s^2, later (forward step) a uniform motion by velocity of about 2 m/s and finally (fist thrusts forward) a uniformly accelerated motion with the acceleration of about 49 m/s^2, reaching a final velocity of about 10 m/s.

Very more difficulty is the motion diagrams interpretation of kicks Yoko-geri (Figs. 5 and 6), in keage we have estimated a final velocity of about 41 m/s and in kekomi, that is a kick of push, we have estimated a final velocity of about 2 m/s.

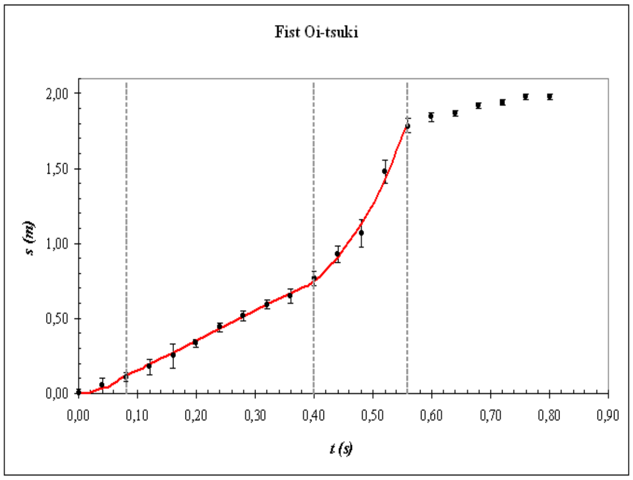

FIGURE 4. Motion diagram of fist oi-tsuki. Curve of the best fit (red line) of the experimental points, calculated by software CassyLab. The curve equation is due a sequential combination of three motions.

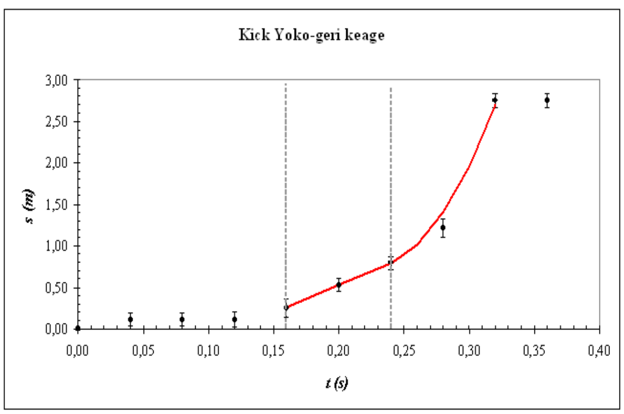

FIGURE 5. Motion diagrams of kick yoko-geri keage. Curve of the best fit (red line) of the experimental points, calculated by the software CassyLab.

IV. CONCLUSIONS

This method can be easily used in a Physics laboratory, it allows students to improve their physical insight and problem solving skills, helps them to understand the difference between the theoretical model and the real system. With the development of our project "The Physics of Karate" [1] we have understood that there are many additional activities, such as hands-on learning, by which it is possible to involve students to study Physics and to understand better the nature of scientific process.

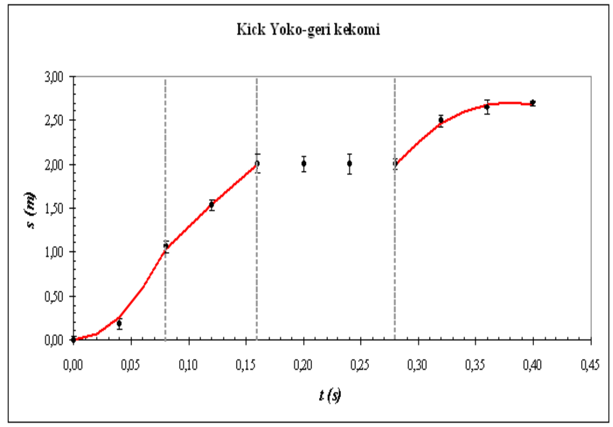

FIGURE 6. Motion diagrams of kick yoko-geri kekomi. Curve of the best fit (red line) of the experimental points, calculated by the software CassyLab.

ACKNOWLEDGEMENTS

I would like to thank Karate Instructor, Master Antonino Giannì, and Laboratory Technician Angelo Budello, who helped me do the experiment and my colleagues Giuseppina Mauro for helping me translate the text into English.

REFERENCES

[1] La Fisica del Karate/Physics of Karate – <http://fisicadelkarate.altervista.org> January 2010

[2] Science Education in European Schools - Selected Practices from the STELLA Catalogue, 32-33, (2009), <http://www.stella-science.eu/pool_good_practices.php>, January 2010

[3]Karate BC – <http://www.karatebc.org/history/index.html> January 2010

[4] Wilk, S. R., McNair, R. E., Feld, M. S., *The Physics of karate*, Am. J. Phys. **51**, 783 (1983).

[5] Diacu, F., *On the Dynamics of Karate*, High School Mathematics Magazine Pi in the Sky, issue 6 March, 9-11 (2003), <http://www.pims.math.ca/pi/issue6/page09-11.pdf>

[6] Chananie, J., *The Physics of Karate Strike*, Journal of How Things Work **1**, 1-4 (1999), <http://www.howeverythingworks.org/journal/Article1.1.pdf>

[7] Gianino, C., *La Fisica del karate. Analisi teorica dell'energia di impatto di una tecnica di pugno*, Didattica delle Scienze e Informatica **259**, gennaio, 43-46 (2009).

[8] Landry, S. G. Denn, G. R., *Classroom Use of Martial Arts Exhibitions*, The Physics Teacher **44**, 430-431 (2006).