УДК 796.92

VIRTUAL REPLACING OF A CIRCLE ARC SEGMENT ON A SKI JUMPING IN-RUN HILL

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Introduction. Motion capture is the preferred analysis method in a wide range of sports applications in research, rehabilitation, physical education and practice. Physical limitations and movement optimisation are of great interest to athletes, coaches, researchers and doctors. Motion capture allows us to learn more about injury mechanisms and prevention. It can also be used to improve a player's technique for better results in various sports applications [6, 7].

To capture human body motion in an ambulatory situation without the need for external emitters or cameras, several systems are available. Mechanical trackers utilize rigid or flexible goniometers which are worn by the user. These angle measuring devices provide joint angle data to kinematic algorithms which are used to determine body posture. Attachment of the body-based linkages as well as the positioning of the goniometers presents several problems [2, 8]. The soft tissue of the body allows the position of the linkages relative to the body to change as motion occurs. Even without these changes, alignment of the goniometer with body joints is difficult, especially for multiple degree of freedom joints [1, 4].

All the methods mentioned above are rather expensive that does not suit a practice of physical education and common sports. The research aims to develop a method of analysis of human motion using common computer programs from Windows and Office. As an example, a study of correlation of the jump length in ski jumping with skier's body's pose parameters at the beginning of take-off and to develop the appropriate model of the pose [9].

The **purpose** of the work was to develop a method of analysis of sport performance using common computer programs from Windows and Office. Methods of mathematical modelling and computer simulation were applied. As an example, a study of correlation of the jump length in ski jumping with skier's body's pose parameters at the beginning of take-off and to develop the appropriate model of the pose. The developed method of working of results of video capturing of the skier at the beginning of taking-off on the table of a trampoline can be recommended for application in the sporting practice, as it allows to determine the angular parameters of body's pose with an absolute error near 0.1°, and is accessible for the wide society of sportsmen and coachers thanks to the use of well-known office information technologies Paint and Excel [5].

Results. Basing on the fundamental features of ski jumping technique, we can assume skier's body position as symmetrical relatively its sagittal plane. Therefore, we can model the skier's body with a plane mechanical chain consisting eight solid links: feet, legs, thighs, a trunk, a head, arms, forearms, and hands. The links of body form between itself joints which could be modelled with kinematical pairs of a fifth class: *p* is an ankle; *s* is a knee; *f* is a hip; *b* is a shoulder and a neck; *a* is an elbow; *m* is a wrist joints (Fig. 1). Because a take-off motion occurs on the table of a trampoline, it is reasonable to measure the joint angles relatively the table plane.

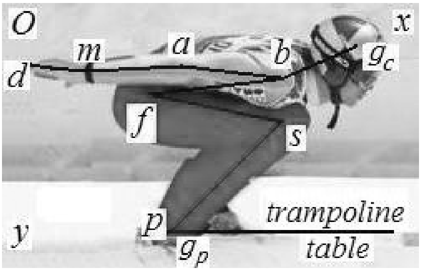

Fig. 1. An image of a ski jumper on the trampoline table and a scheme model of his body with the rectangular co-ordinate system xOy [3]

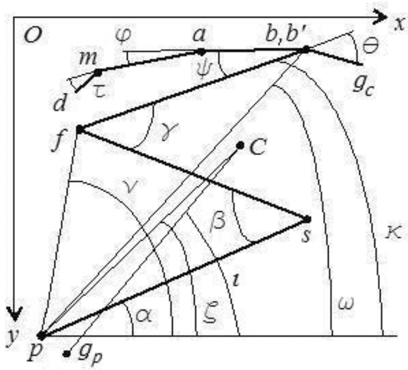

Fig. 2. Kinematic scheme of the body

We can describe the pose of a skier's body relatively skis considering feet as a provisionally immobile link. Then the amount of degrees of freedom of the body could be defined using the formula for a plane kinematical chain:

$$W = 3n - 2P_5 - P_4 = 7, (1)$$

where $n = 7$ is a number of mobile links (legs, thighs, a trunk, a head, arms, forearms, and hands); $P_5 = 7$ is a number of kinematical pairs of the fifth class (an ankle, a knee, a hip, a shoulder, a neck, an elbow, and a wrist joints); $P_4 = 0$ is a number of kinematical pairs of the fourth class [12].

Therefore for determination of skier's body pose, we need seven parameters. Because an amount of kinematical pairs of the fifth class is seven, we can take for these parameters seven joint angles $(\alpha, \beta, \gamma, \theta, \psi, \varphi, \tau)$ which are shown on the kinematical scheme of the skier's body (Fig. 2). Except for these seven, we took additionally three parameters which were accepted to characterize the pose of a jumper (Fig.3). They are angles of a slope to direction of skier's motion (on the table of a trampoline) of straight lines which pass through the axes of ankle and shoulder joints (angle ω), through the axes of ankle and hip joints (angle ν), through the axis of ankle joint and COM (*p. C*) of the body (angle ζ), and also through the axes of the hip and shoulder joints (angle κ).

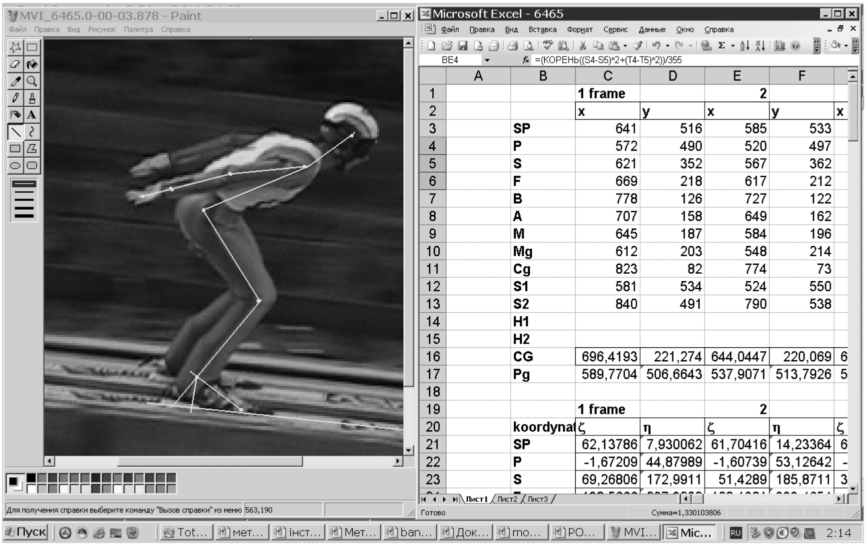

Fig. 3. Paint and Excel desktop [10, 11]

Conclusion. The developed method of working of results of video capturing of the skier at the beginning of taking-off on the table of a trampoline can be recommended for application in the sporting practice, as it allows to determine the angular parameters of body's pose with an absolute error near 0.1°, and is accessible for the wide society of sportsmen and coachers thanks to the use of well-known office information technologies Paint and Excel.

An eight-links kinematics model of skier's body showed its usability for the analysis of dependence of jump length on skis from a trampoline on the skier's body's pose at the beginning of taking-off. It is set as a result of multiple correlation analysis, that a part of variation of the model parameters in the total variation of jump length is equal almost 53 %, and relative correlation is strong and significant ($R = 0.727$; $p < 0.005$).

Keywords: ski jumping, in-run hill profile, mechanical and mathematical modelling.

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