ESTIMATION OF TEMPORAL PARAMETERS IN SKI JUMPS USING WEARABLE SENSORS

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INTRODUCTION

Take-off during ski jumping is probably the most important phase as it directly influences the whole performance [1]. It is then of particular interest to precisely identify key events such as when the take-off movement is initiated (TS), when the toes leave the ground (TO), when both legs are fully extended (LE) or when the ski jumper achieved his final flight posture (TE). In this paper, we propose a wearable system that records the accelerations and the angular velocities of ski jumpers. Based on these signals, we then automatically extract four key events during takeoff: TS, TO, LE and TE. We use these instants to derive timing information during takeoff in hill jumps.

METHODS

Our system was composed of 5 wireless Inertial Measuring Units (IMU) attached on the sacrum, the thighs and the shanks (Figure 1). Each IMU included one tri-axial gyroscope (± 600◦/s in-lab and ± 1200◦/s in field), one tri-axial accelerometer (± 5g in-lab and ± 10g in field) and an embedded datalogger recording the signals at 200Hz. Key event such as TS was detected from the high thigh pitch angular velocities, TO was identifiable by high shank accelerations along the longitudinal axis, LE by looking at differential angular velocities between shanks and thighs and TE event by peaks in the roll shank angular velocities. Our algorithm searched for these peaks using a Lorentzian curve fitting algorithm into automatically identified regions of interest in the signals.

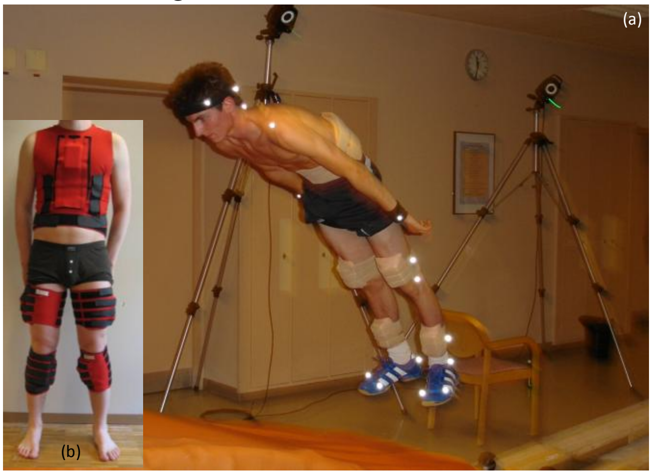

Figure 1: (a) In lab setup with optical markers and wearable IMUs, (b) In field setup with wearable IMUs

We carried out laboratory measurements on 5 young ski jumpers (17.2±3.3 years) wearing the system and performing a total of 40 simulation jumps with wheeled board on 5 meters-long ramp. Vicon optical motion capture was used as reference to manually identify the key events (Figure 1). The accuracy (mean difference) and precision (standard deviation of the difference) were estimated by considering the difference between our algorithm and the reference. We additionally applied our system on 36 jumps obtained in medium jumping hill (HS-77m) with 13 young ski jumpers and compared temporal parameters obtained with our system to those estimated by two professional trainers using a 50 Hz video camera system .

RESULTS AND DISCUSSION

Table 1 shows the errors for the detection of temporal parameters compared to the reference during laboratory measurements. The errors for detecting LE and TO are low, while the detection of TE presents larger errors due to the difficulty to precisely annotate the Vicon measurement for TS. Table 1 shows also during hill jumps the difference between video annotations by the two trainers (T1 and T2) and our system. These results highlight the importance of the difference between trainers and shows that the most repeatable time event between trainers is TO. Our system detected systematically earlier TS and slightly later TO, compared to trainers. For TE, our accuracy (mean difference) is better that the mean difference between trainers with similar precision (SD). Our precision was less than 50ms for TO and LE and in the same range as the trainers for TE.

CONCLUSIONS

The wearable system that we proposed was able to provide accurate and precise results during simulated ski jumps. It was successfully used during hill jumps providing automatic detection of meaningful temporal events. These results can improve the accuracy of manually video labeling and help trainers and athletes to improve ski jumping trainings using quantitative and objective parameters.

ACKNOWLEDGEMENTS

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Table 1: Mean errors ± standard deviation in milliseconds for the detection of TS, TO, LE and TE compared with the Vicon system (In Lab). Differences between video annotations (for trainer T1 and trainer T2) and our IMUs system (Hill Jump)

		TS	TO	LE	TE
In Lab		–9.7±47.7	–2.2±12.2	2.5±10.4	18.9±28.7
Hill Jump	**T1-IMU**	–64.6±47.5	9.4±37.1	40.3±25.1	43.4±180.1
	T2-IMU	-37.9±43.4	36.1±46.7	35.3±36.5	-72.7±198
	T2-T1	-12.8±44.0	-12.8±10.7	18.9±17.0	130.0±130.0