ALPINE SKI RACING GATE CROSSING DETECTION USING MAGNETOMETERS

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INTRODUCTION

In alpine ski racing performance is defined as total race time. To provide higher time resolution section times can be measured. However, from a performance analysis point of view they might not provide sufficient resolution; it would be preferable to have a time measure at least at each gate. The aim of this project was to propose and validate a gate crossing system allowing to obtain gate-to-gate timing for an entire race. The system should be easy to use and applicable in field without complex setup and analysis.

METHODS

An inertial measurement unit including a magnetometer sampling at 125Hz was fixed to the lateral side of the right thigh. Strong bar magnets were buried at each gate of the run, causing a distortion in the local magnetic field for close distances to the gates. While skiing down the run, these distortions could cause peaks in the measured magnetic field. Strapdown integration was used to compute the sensor's absolute orientation (Favre et al., 2006). The peaks were detected on the L1 norm of the high pass filtered signal expressed in the global frame. The method was validated on 12 runs of a giant slalom course against high speed video measurement. The cameras (250Hz) were filming the gates number 3 and 16 laterally. The cameras were opto-electronically synchronized with the IMU and three independent raters extracted the gate passing events from the videos. A gate passing was defined as the moment the center of the outside ski boot passed the gate.

RESULTS

Intra-rater correlation coefficient (ICC 2,1) of video gate passing detection was >0.999 with average maximum rater disagreement of 3.4ms (<1 video frame). All gate crossings were successfully detected with the magnetometer, independent of gate contact. For both left and right turns, the method´s precision (i.e. the error standard deviation) was 9.3ms and 8.3ms, respectively. However, the method´s accuracy (i.e. the mean error) substantially differed between the left and right turn (23.9ms versus 2.6ms).

DISCUSSION

The proposed method allowed detecting gate crossings fully automatic with a simple setup. It was robust and allowed detecting gate crossing also when no gate contact occurred. The position difference between inside and outside leg

led to a time offset during left turns but without compromising the precision, thus still allowing a valid analysis. The offset could be corrected by placing a second magnetometer on the contralateral thigh or attaching a single magnetometer on the sacrum.

CONCLUSION

The proposed method was both valid and proved highly practical. With very little effort gate-to-gate timings of entire runs can be provided, allowing a more detailed analysis of the athlete's skiing performance.

REFERENCES

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