Visual Feedback for Pacing Strategies in Road Cycling

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The right choice of a pacing strategy for a time trial race is important and often difficult to establish. Methods are now available to generate pacing strategies that are optimal, however, only in a mathematical sense. Until now, they were tested in practice only under laboratory conditions [1]. Pacing strategies are generally based on two mathematical models: (1) to describe the relation between power output and speed [2], and (2) to describe the fatigue of the rider related to the power output [3]. The quality and validity of these pacing strategies relies on the accuracy of the predictions made by those models.

Our goal is to leave laboratory conditions and move on to the field. One problem there is that deviations within the physical model parameters like wind, road surface, or slope may lead to premature exhaustion if the cyclist follows precomputed speed, power or time. Thus, we need a way to guide the cyclist on a pacing strategy following the precomputed exhaustion (remaining anaerobic energy (ean)) and adapting precomputed power and speed.

Besides proposing a suitable real-time adaptation of the strategy we show that the cyclist can successfully complete the prescribed ride with only small overall deviations from the strategy, using one of three kinds of feedback modes.

Methods

We developed a mobile application for android smartphones based on the Pegasos framework [4]. Smartphones have several advantages compared to cycling computers: better computational capacities, less restrictions, and usually a larger screen.

Two cyclists tried our adaptive feedback on a 4 km hill climb with an optimal pacing strategy that was computed with reduced maximal anaerobic capacity and critical power and therefore not completely exhausting. Thus, the cyclists were able to test three different adaptive feedback screens (power, speed, ean) on the same day. All feedback screens had the same base layout with a scale from red to green to red (see figure on the left) Three labels show current measured value, target value and the difference between them.

Adaption of the pacing strategy was realized by modifying target power and speed values in respect to the error in remaining

		Power	Ean	Speed
Cyclist 1	Finish Ean (j) MAE	-136 126	-162 87	-230 298
Cyclist 2	Finish Ean (j) MAE	-273 248	-7 134	359 388

Tab. 1 The difference between measured values and computed pacing strategy is shown for rides with adaptive power, ean, and speed feedback. (MAE = mean absolute error)

anaerobic energy. This means that the cyclists are steered back to following the given exhaustion strategy. A nonlinear modification with saturation, obtained by

$$Target = Reference - m \cdot tanh\left(-k \cdot Ean_{\{diff\}}\right)$$

has proven suitable. For the ean feedback screen, no modifications are necessary.

Results

The results show, that the cyclists followed the given pacing strategy with a mean absolute error between recorded and precomputed remaining anaerobic energy of less than 500 joule. 500 joule are consumed in 20 seconds when cycling with 25 W more or in a few seconds when cycling out of the saddle. Thus, we can say that the riders were able to follow the given pacing strategy accurately in terms of exhaustion. The ean feedback showed the best results despite of the abstract nature of this unusual measure.

Conclusion

With our feedback device, cyclists can accurately follow a precomputed exhaustion strategy. The feedback guides the cyclists on a given exhaustion strategy. All of the three feedback options (power, speed, and ean) delivered suitable results.

References

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