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Exploration and Visualization of Race Biking Performance

Introduction

We develop methods and tools for visual analytics to help analyzing performance parameters in race biking (Dahmen 2010). The work described in this paper is done as a part of the Powerbike project at the University of Konstanz, the goal of which is to provide methods to model, analyze, visualize, and improve the performance of athletes during the training and in competition in cycling. In a laboratory, the measurements combined from a series of devices, including conventional bike computers, GPS-recorders, and power meters are processed. The data is recorded by different devices and synchronized and fused beforehand, yielding a collection of time series (with sampling rate of 1Hz) of the various performance parameters. The paper addresses the problem to present all this data on one screen for the trainer or cyclist so they can quickly grasp the main trends in it to be able to make decisions about further training.

Overview of the Existing Visualization Tools

Although we did not find any scientific study on our particular visualization problem, there are commercial products for which visual tools with only basic functionality are provided. We discuss visualization methods that are available in a supplementary software of CompuTrainer, Tacx and SRM.

CompuTrainer provides a professional bicycle simulator. USA Triathlon and USA Cycling teams rely on the CompuTrainer to test and train their performance.

Tacx sells three types of ergometers: VR Trainer and Ergotrainer for professional athletes and Cycletrainer for hobbyists.

SRM is a training system developed to measure power of the cyclist while riding. In the software SRMWin basic visualization tools are supplied.

All the visualizations that come with these products depict raw time series. Although slightly different, conceptually they use the same idea and visualize all the data in one plot using multiple vertical axes. See Figs. 1, 2 and 3. This kind of visualization suffers from cluttering making it difficult to extract the essential information from it. Moreover a user cannot adjust the level of detail of the visualization. Our proposed visualization technique overcomes these shortcomings.
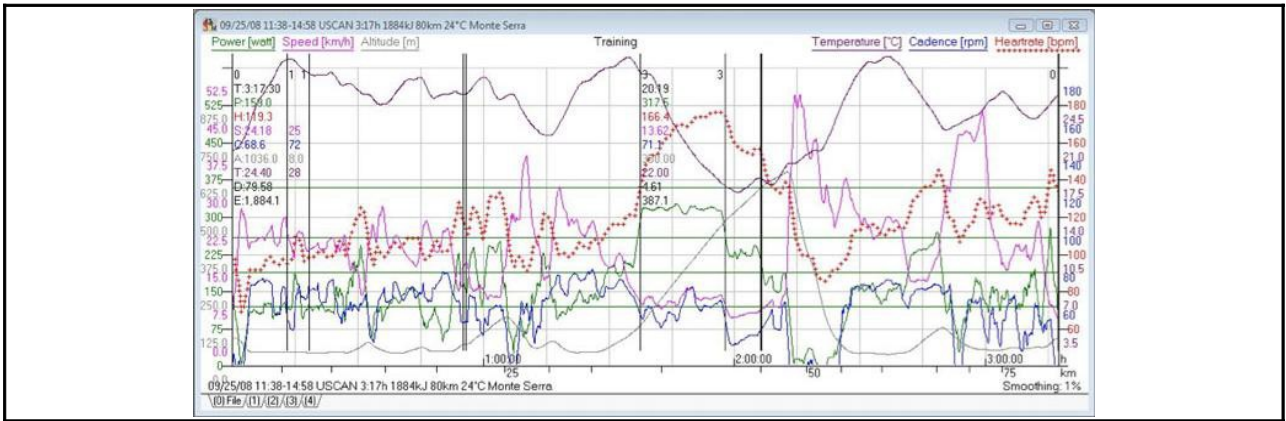
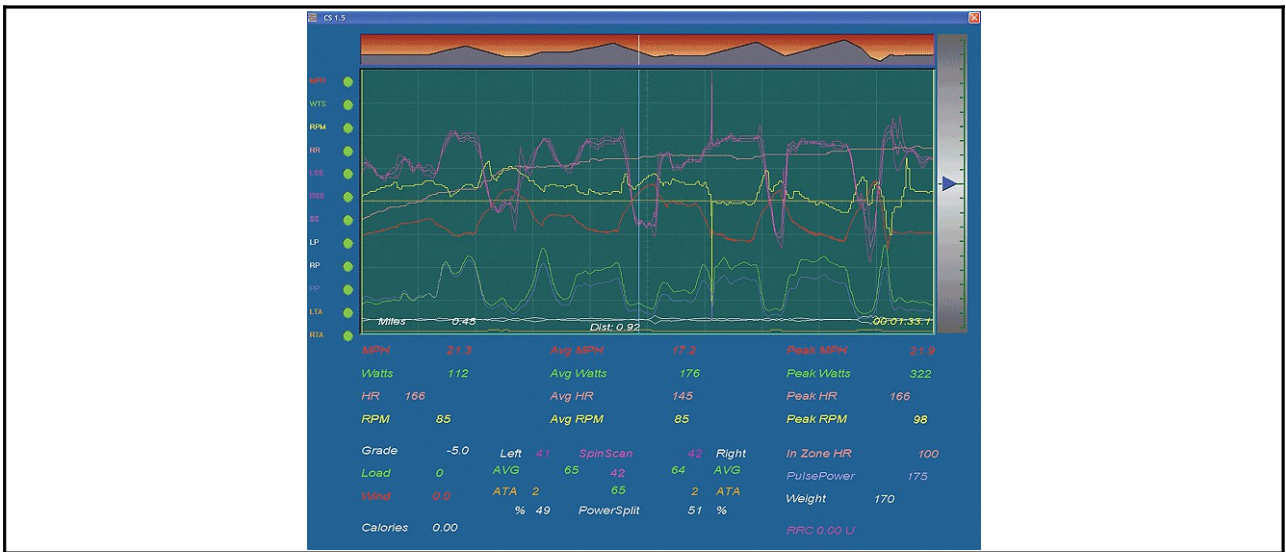Fig.1: Visualization of performance parameters in SRMWin.

Fig.2: Visualization of performance parameters in the CompuTrainer supplementary software.

Fig.3: Visualization of performance parameters in Catalyst – the supplementary software for the Tacx er-gometers.

Proposed Visualization Technique

The Powerbike project spans a range of research activities for cycling, requiring different visualization tasks to be performed. These can be grouped in three categories:

- visualization of the course, rider's performance and more for the simulation in the laboratory;
- visualization as feedback in the field to the cyclist;
- visualization for the analysis of the performance.

In this paper we focus on developing visual analytic tools for the analysis of performance after completing a particular course by a cyclist either in the lab or the field.

To solve this problem we follow the paradigm: "Analyze First – Show the Important – Zoom, Filter and Analyze Further – Details on Demand" (Keim 2006). We aggregate all the data recorded during the course in one graph, called CourseView. The principal axes for the data display are speed and distance. First of all the so called base plot curve is drawn, that describes the speed of the cyclist. After that for each data series we form so called *information chunks* and then depict them on this curve. Information chunks show additional data; e.g., power, heart rate, cadence. They are computed for each data series separately with the following automatic method. Firstly, all the extrema of a data series are found. Then, based on the separate parameter d_i (where $i=1..N$, N is the number of data series) for each data series we put an information chunk at a point of extrema if the difference to the previously selected extrema value is more than d_i. Finally, all the chunks are carried over to the corresponding positions on the main graph. If the positions of some of them overlap, then they will be put next to each other. We depict a chunk in the form of rectangle. The height of all the rectangles is constant and represents the maximum value of a parameter. A part of it is hatched, corresponding to the current value of the performance parameter. Additionally plus or minus sign is put on top of the rectangle if it represents maximum or minimum value correspondingly. See Fig. 4.

Discussion and Future Work

In order to analyze the proposed method we have visualized the performance of a bicyclist on a course (Schienerberg) with different parameters, see Fig. 4. Interactive variation of parameters allows the user to change the number of information chunks. This allows to make the visualization less cluttered. That is why, when analyzing a course data one can quickly find the regions of interest using large values for parameters. After that the region of interest can be zoomed in and on demand standard visualization in form of curve plots with multiple vertical axes will be shown.

Our visualization has also drawbacks. Not all the available space is utilized for it. It is also hard to track information chunks in correct order, if the base plot curve fluctuates a lot. One must carefully track the base plot while reading the information. Also it is not easy to understand the behavior of a particular performance parameter globally. However, analyzing small regions could be of advantage. Consider the region which is marked by a rectangle in the Fig 4a. Looking at it a user can clearly see that power has reached extrema three times. The parameter d for the power is 45 W. This means it fluctuates in this region with magnitude of more than 45 W. All the others performance parameters however, such as cadence, work per heart beat, heart rate and pedal force behave more or less constant with respect to their corresponding parameters d_i, of course.

In the future we are going to conduct a series of user studies together with sport scientists to evaluate the use of the proposed visualization method more thoroughly. In the current work we used rather simple approach to determine positions of information chunks. It will be of great interest to collaborate with sport scientists to develop algorithms, that will incorporate not only the pure mathematical reasoning, but also the knowledge of the sport science.

Conclusion

In this work a new method for the visualization of performance parameters after completing the course in road bicycle racing is proposed. The method employs the idea of extracting the most meaningful information out of the recorded data series and putting it on the base plot. The extraction mechanism depends on the parame-ters defined by a user. This makes the visualization interactive and allows to analyze the data with different level of detail. The advantages and drawbacks of the proposed method are discussed. Finally, the directions for the future work are designated.
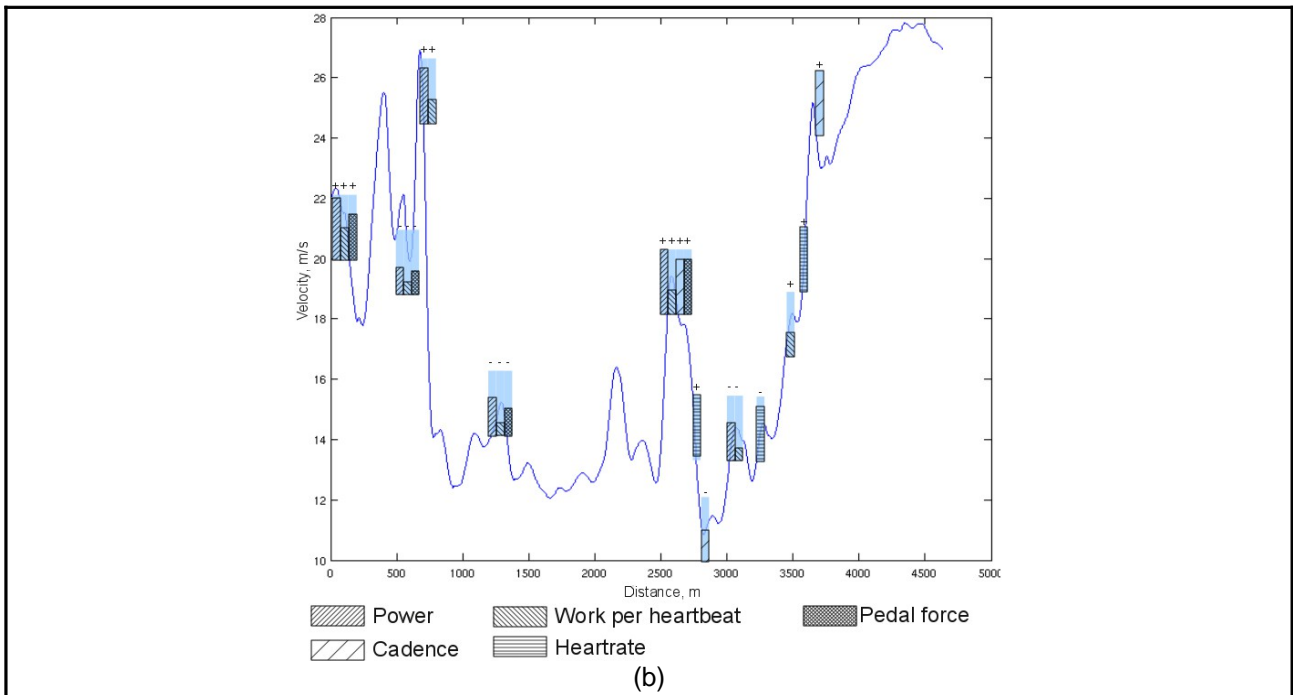

(a)
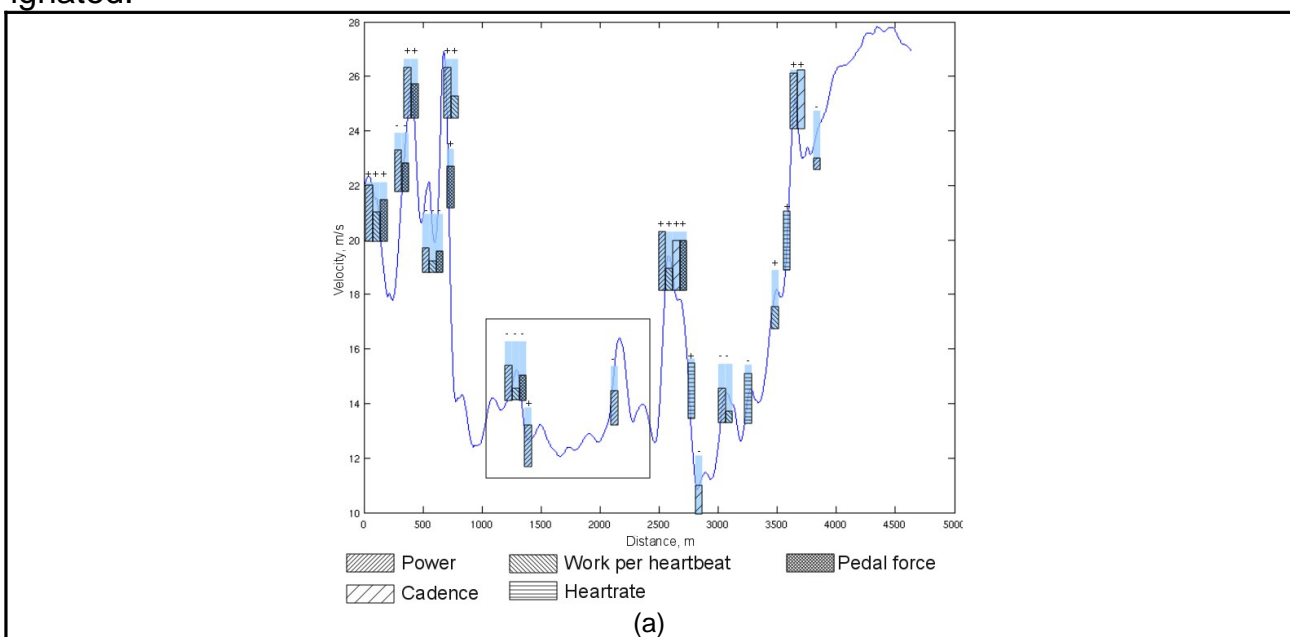
Fig.4: Visualization of performance parameters with different parameters. See parameters values in the table below.

Parameter d_i	Value for Fig. 4a	Value for Fig. 4b
Power	45 W	85 W
Work per Heartbeat	40 J	40 J
Pedal force	60 N	80 N
Cadence	20 rpm	20 rpm
Heartrate	13 bpm	13 bpm

Literatur

Dahmen, T., Byshko R., Roeder, M., Mantler, S., & Saupe, D. (2010). Paper. Validation of a Model and of a Simulator for Road Cycling on Real Tracks. Submitted.
Keim, D. A., Mansmann F., Schneidewind, J, & Ziegler, H. (2006). Paper. Challenges in Visual Data Analysis. IEEE Computer Society.
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