Related projects

• BrainCycles - Differentiation of oscillatory brain networks subserving bicycling and walking movements in Parkinson’s disease
• Analysis of chaos in indoor pedaling motion

Invitation

Bachelor and master students are welcome to do projects and theses with us. We are also looking for riders to participate in empirical studies and for student assistants to work in our group in the research project Powerbike. The focus is on the further development of our bicycle simulator. Currently, possible tasks include:

• Enhancement of the GUI in particular to exploit touchscreen technology
• Integration of additional sensor signals such as heart rate, cadence, and pedalling power via the ANT protocol and TCP-IP
• Integration of height profiles measured using a differential GPS and inertial navigation system
• Improvement of the synchronization of video with the cycling speed

Selected publications


Project members

Prof. Dr. Dietmar Saupe
Dr. Maciej Gratkowski
Dipl.-Ing. Thorsten Dahmen
Dipl.-Ing. Juan-Carlos Quintana-Duque
Alexander Artiga Gonzalez
Nitin Sharma

Contact

Prof. Dr. Dietmar Saupe
dietmar.saupe@uni-konstanz.de
Fachbereich Informatik und Informationswissenschaft
Universität Konstanz
Fach 697
78457 Konstanz, Germany
http://www.informatik.uni-konstanz.de/saupe/powerbike/
We develop methods for data acquisition, analysis, modeling, optimization and visualization of performance parameters in endurance sports with emphasis on competitive cycling.

Measurements from a palette of devices, including common bike computers, GPS recorders, and power meters, are combined requiring data fusion and synchronization. A part of the project is a bicycle simulator based on a commercial ergometer and our own PC-based control software. The main components of the simulation are:

- computer controlled pedal resistance according to the height profile of a cycling track
- the recording and visualization of training data measurements (speed, cadence, power, heart rate, height profile etc.)
- video display of the cycling track at the current position.

Our system contains three layers. In the parameter layer the following signals are recorded to develop and test the models: speed, cadence, heart rate, power, gear ratio, GPS coordinates, video, VO2, lactate levels.

Given the necessary parameters, the simulator is able to produce a brake force that comprises forces due to a gradient, air resistance, friction and acceleration. The bicycle simulator allows realistic training in a laboratory environment.

The model layer consists of physical models of the track and its environment and physiological models of human performance. These models are used to predict the total riding time for given pacing strategy, to fill in missing data, to estimate power from other variables, and to fit model parameters to data measurements.

In the computational layer optimal control algorithms are used to compute pacing strategies that minimize time to arrival or exhaustion for given total race.

Why road cycling?

In comparison with other endurance sports road cycling offers more opportunities for research:

- Mechanical model of cycling available
- For endurance sports, physiological models may be feasible and useful
- Lab and field studies possible
- Sensors integrate unobtrusively
- Performance measurement (power) readily available
- Popular sport: healthy, fun :-)

Equipment

We use a differential GPS device to extract high-precision trajectories of real cycling tracks. In track sections, where the differential GPS quality is degraded due to obstacles along the track, we measure cycling speed and power using a power meter in conjunction with a commercial GPS device to estimate the gradient and thus enhance the differential GPS measurements.

Mechanical model

The equilibrium of the pedaling force \( F_{ped} \) and resistance forces defines the relation between pedaling power \( P_{ped} \) and cycling speed.

The resistance forces are composed of the gravitational force \( F_{grav} \), frictional losses in the wheel bearings \( F_{bear} \), rolling resistance \( F_{roll} \), and (optionally) the slipstream force \( F_{slip} \).

\[
\frac{dh}{dx} + \frac{1}{2} c_d \rho A x^2 + \mu m g + (\beta_0 + \beta_1 \dot{x}) + \left( m + \frac{I_c}{r_w^2} \right) \ddot{x} = \eta \frac{L}{r_w} - F_{ped}
\]

Why road cycling?

In comparison with other endurance sports road cycling offers more opportunities for research:

- Mechanical model of cycling available
- For endurance sports, physiological models may be feasible and useful
- Lab and field studies possible
- Sensors integrate unobtrusively
- Performance measurement (power) readily available
- Popular sport: healthy, fun :-)

Equipment

We use a differential GPS device to extract high-precision trajectories of real cycling tracks. In track sections, where the differential GPS quality is degraded due to obstacles along the track, we measure cycling speed and power using a power meter in conjunction with a commercial GPS device to estimate the gradient and thus enhance the differential GPS measurements.

Mechanical model

The equilibrium of the pedaling force \( F_{ped} \) and resistance forces defines the relation between pedaling power \( P_{ped} \) and cycling speed.

The resistance forces are composed of the gravitational force \( F_{grav} \), frictional losses in the wheel bearings \( F_{bear} \), rolling resistance \( F_{roll} \), and (optionally) the slipstream force \( F_{slip} \).

\[
\frac{dh}{dx} + \frac{1}{2} c_d \rho A x^2 + \mu m g + (\beta_0 + \beta_1 \dot{x}) + \left( m + \frac{I_c}{r_w^2} \right) \ddot{x} = \eta \frac{L}{r_w} - F_{ped}
\]

Why road cycling?

In comparison with other endurance sports road cycling offers more opportunities for research:

- Mechanical model of cycling available
- For endurance sports, physiological models may be feasible and useful
- Lab and field studies possible
- Sensors integrate unobtrusively
- Performance measurement (power) readily available
- Popular sport: healthy, fun :-)

Equipment

We use a differential GPS device to extract high-precision trajectories of real cycling tracks. In track sections, where the differential GPS quality is degraded due to obstacles along the track, we measure cycling speed and power using a power meter in conjunction with a commercial GPS device to estimate the gradient and thus enhance the differential GPS measurements.

Mechanical model

The equilibrium of the pedaling force \( F_{ped} \) and resistance forces defines the relation between pedaling power \( P_{ped} \) and cycling speed.

The resistance forces are composed of the gravitational force \( F_{grav} \), frictional losses in the wheel bearings \( F_{bear} \), rolling resistance \( F_{roll} \), and (optionally) the slipstream force \( F_{slip} \).

\[
\frac{dh}{dx} + \frac{1}{2} c_d \rho A x^2 + \mu m g + (\beta_0 + \beta_1 \dot{x}) + \left( m + \frac{I_c}{r_w^2} \right) \ddot{x} = \eta \frac{L}{r_w} - F_{ped}
\]

Why road cycling?

In comparison with other endurance sports road cycling offers more opportunities for research:

- Mechanical model of cycling available
- For endurance sports, physiological models may be feasible and useful
- Lab and field studies possible
- Sensors integrate unobtrusively
- Performance measurement (power) readily available
- Popular sport: healthy, fun :-)

Equipment

We use a differential GPS device to extract high-precision trajectories of real cycling tracks. In track sections, where the differential GPS quality is degraded due to obstacles along the track, we measure cycling speed and power using a power meter in conjunction with a commercial GPS device to estimate the gradient and thus enhance the differential GPS measurements.

Mechanical model

The equilibrium of the pedaling force \( F_{ped} \) and resistance forces defines the relation between pedaling power \( P_{ped} \) and cycling speed.

The resistance forces are composed of the gravitational force \( F_{grav} \), frictional losses in the wheel bearings \( F_{bear} \), rolling resistance \( F_{roll} \), and (optionally) the slipstream force \( F_{slip} \).

\[
\frac{dh}{dx} + \frac{1}{2} c_d \rho A x^2 + \mu m g + (\beta_0 + \beta_1 \dot{x}) + \left( m + \frac{I_c}{r_w^2} \right) \ddot{x} = \eta \frac{L}{r_w} - F_{ped}
\]

Why road cycling?

In comparison with other endurance sports road cycling offers more opportunities for research:

- Mechanical model of cycling available
- For endurance sports, physiological models may be feasible and useful
- Lab and field studies possible
- Sensors integrate unobtrusively
- Performance measurement (power) readily available
- Popular sport: healthy, fun :-)