# Introduction

#### Background

Since the first bicycle race was held on the 31 May 1868 at the Parc de Saint-Cloud, Paris, various bicycle games have emerged in large numbers, including road bicycle, tracking cycling, mountain bike and so on. In different kinds of bicycle race, riders are always looking to minimize the time required to cover a given distance.

Besides the fitness of the athletes, appropriate strategies also play a decisive role in a cycling race. A rider can keep a constant speed in the whole game. And he can adjust his speed according to the landform and wind, as well. He can exceed his limits under a certain condition at the price of riding slowly in the next period.

However, everyone has different properties in riding. For example, someone may specialize in races that have multiple long climbs (a climber), while another specializes in producing extremely high power for short periods of time (a sprinter). This difference can be described as discrepancy in power curve, which indicates how long a rider can produce a given amount of power. Given a particular rider’s capability according to that rider’s power curve, how should that rider apply power while traversing a given time trial course?

Moreover, in a team time trial, a team often ride in a line to reduce the air resistance. Given that the team consists of different type of riders, how to arrange the speed of the team and how to arrange the lead rider? These questions are discussed in this paper.

#### Restatement of the Problem

* Develop a model that can be applied to any type of rider that determines the relationship between the rider’s position on the course and the power the rider applies.
* Define the power profiles of riders of different types and different genders.
* Apply the model on various time trial courses.
* Determine the potential impact of weather conditions.
* Determine how sensitive the results are to rider deviations from the target power distribution.
* Discuss how to extend your model to include the optimal power use for a team time trial
* Write a two-page rider’s race guidance for a Directeur Sportif of a team.

#### Our Approach

# Data

#### Data Collection

The data we used mainly include geographic information of the racing course, typical power curves of different kinds of cyclists.

The data sources are summarized in Table 2.

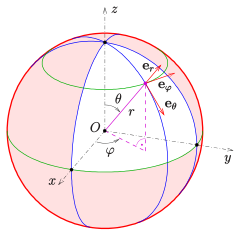
|  |  |  |
| --- | --- | --- |
| Database name | Website | Data Type |
| Google Earth | https://earth.google.com | Geography |
| SRTM1 | https://www2.jpl.nasa.gov/srtm | Geography |
| ODP1 | https://data.opendataportal.at/dataset/dtm-europe | Geography |
| \*\*\*powercurve |  |  |

## Data preprocess

Geographic information of the racing course

To get the 3D model of the cycling course, we looked up the rider manual. We uniformly sampled points on the racetrack and marked them on Google Earth. In this way, the longitude and latitude information can be exported. Then we reached the elevation information of these points using the database SRTM1 and ODP1.

In order to simplify the data process procedure, we transform the course from terrestrial coordinate system to a space rectangular coordinate system, whose origin locates at the start point and whose x’, y’, z’ axis orient to south, east, sky respectively. The detailed procedures are shown at below.



In the old coordinate system shown as , the coordinate of the start point can be represented as:

The new coordinate is shown in the figure, . Its basis vectors can be represented as:

For the points in the course,

图表

描述已自动生成图表

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(此处放平滑前的路径图和高度图)

As we can see, there are plenty of spines on the figure. The fluctuation of the coordinate is caused of the point sampling on the map. The unrealistic ascent and descent will disturb our simulation to a large extent. Here we smoothed the data using convolution.

图表

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(此处放平滑后的路径图和高度图)

# Physical model of cyclist

图示

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To simulate the kinetic processes of a cyclist and his/her bicycle, a force analysis is inevitable. In general, the resistance on a cyclist and his/her bicycle includes air drug, air friction, rolling resistance, the downward slope component of gravity.

The air drug is normal to the surface of the resisted body, felling like the pressure of the wind. It can be represented as:

The factor is the drag coefficient of air, is the density of air, is the frontal area of cyclist and his/her bicycle, is the relative velocity between air and cyclist.

The air friction is tangential to the surface. For an unstreamlined body such as a bicycle and rider, the pressure effect is much the larger. As a result, the air friction can be ignored.

The rolling resistance can be represented as:

The is the pressure of the wheels; is the radius of the wheels; is the rolling resistance coefficient, which varies with the condition of the road, the material of the wheel and the air pressure of the pneumatic tire.

The downward slope component of gravity can be represented as:

Where is the total mass of cyclist and bicycle, is the gravitational acceleration, is the angle between slope and horizontal.

In this way, the kinetic equation of cyclist and bicycle can be represented as:

where is the mechanical efficiency of bicycle, is the output of the cyclist, is the vector of velocity of cyclist and wind respectively.