Optimising strategies for long-distance cycle races

Matthew Shirley

20th January 2025

Introduction

Cycle racing is a lucrative and competitive sport:

- In 2006, 2007, 2008, and 2020 Tour de France the winning margin was less than 1 minute for races taking approximately 90 hours.
- The winner of the 2023 Tour de France won at least €500 000.
- Similarly, the 2022 Men's London Marathon was won by 33 seconds with a prize of £55000.

Hence, there is a large incentive to find ways to improve your chances of winning long distance races.

Introduction

There are three main ways to improve the chances of winning a cycling race:

Technological advances

e.g. lighter, more aerodynamic bikes

Physiological advances

e.g. improved training routines

Better strategies

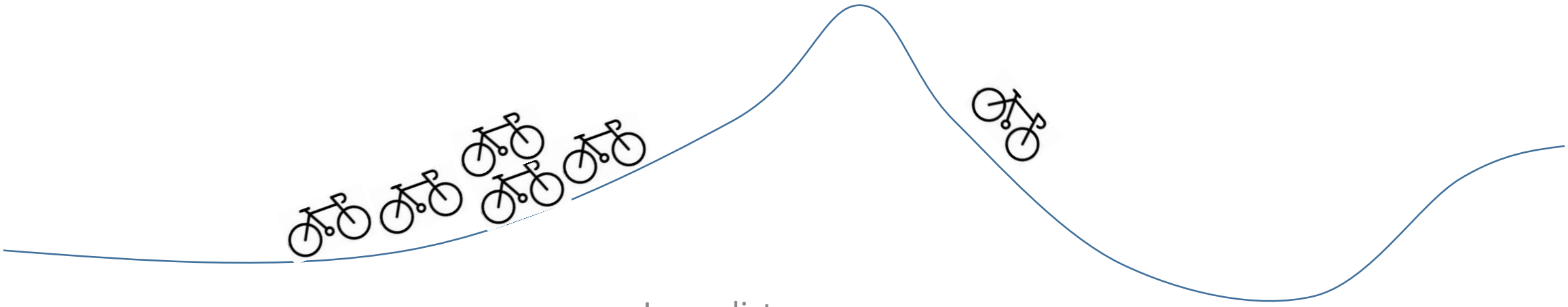
Bike races

Peloton

- A group of riders riding together.
- This reduces air resistance by 30%.
- Therefore energetically favourable to stay in peloton as long as possible

Breakaway

- An individual rider (or small group) who rides out ahead of the peloton in an attempt to win.
- The extra speed and air resistance means the rider must exert a greater force.
- If the breakaway occurs to soon, then fatigue means the peloton may catch up.



Causes of Fatigue/Exhaustion

Muscle fatigue can be caused by:

- Build-up of lactic acid
- Build up of Phosphate ions

Exercise also requires nutrients, to the total amount of work possible is limited by the energy supply in the body.

Challenge

Develop a coupled mathematical model for:

1. The motion of cyclists over a long distance race course.
2. The effect of fatigue/energy consumption on the motion of cyclists.

Then use the model to predict the optimum breakaway point to win the race in the shortest possible time.

Possible extensions:

- How do different physiological models compare.
- How does the optimal strategy alter over a multi-stage race? Is one big breakaway better than several smaller ones? How should recovery between stages be modelled?
- Would the model also apply long distance running or swimming races?

Mathematics

Mathematical Modelling:

- Modelling Physical Systems
- Asymptotics
- Biological Modelling
- Discrete Modelling

Scientific Computing:

- Numerical Solution of ODEs
- Optimisation
- Using real-world data