Problem Chosen	2022 MCM/ICM Summary Sheet	Team Control Number
A		2224504

The time trial in the bicycle race is the easiest form of the cycling sports and in the forms of the race, the road time trial resembles the cross-country skiing race. The time trial can be divided into two types, one is ITT, known as individual time trial, the other one is TTT, known as team time trial. In our paper, we will concentrate more on ITT rather than TTT.

In our models, we first give out the power curve for different types of athletes, while also considering the personal differences of them. Then, with the change of weather condition, our results will have a change. We analyze the track of the Tokyo Olympic race and build up one track designed by ourselves as well. At last, we try to give out the analysis of the team time trial.

To say in a detailed way: We divide the whole problem into four models. In the first part, namely a lead-in model, we consider the condition that the participants ride in a straight direction while calculating their speed and power consumption. We give several formulas and equations as we take the wind force into consideration, and the model can be transfered to the combination of maths and force analysis. While considering the external factors, we establish the mathematical model of speed, acceleration and power.

In the second part, which is our Model A, we take the condition going around a curve into consideration, as riders in a race will experience several turnings, we apply geometry models and physical models in circular motion, and build the relationship among the variables themselves, especially the speed and power consumption.

Next, in our Model B, we first cut the track into several pieces, which is the uphill part, part with a constant speed and the downhill part, at the same time, applying physical models to give it a solution. After doing that, we give an analysis on the track in Tokyo Olympic Games while designing our own track based on our thoughts and calculations. Our designed track is shown in a figure in that part.

Then, a supplementary model will be shown to humbly deal with the condition of TTT, requiring some of the members breaking wind, rotating and some participants like sprinters can give a sprint in the end of the game as the mark only counts on the best four in six.

Finally, a sensitivity analysis is given to decide the sensitivity of time according to speed change, shown in the figures. Meanwhile, the strengths and weaknesses along with the drivers' guide for the team director is shown.

Contents

1 Introduction

1.1 Background

The time trial in the bicycle race is the easiest form of the cycling sports and in the forms of the race, the road time trial resembles the cross-country skiing race.

As said in the problem, there are many types for the bicycle road races, including the criterium, a team time trial and an individual time trial. In these races, the rider's chance to succeed will differ due to the racing time, various types of events, routes and the ability of the participants. In the individual time trial, every cyclist should ride on a fixed route, and the winner is the one who consumes the least time, the total distance of the road will be 5 to 40 kilometers in big races on a flat and extended road or a circular road.

While in a team time trial, the winner only depends on the first 4 or 3 participants in every team. Thus, in a TTT, every team can adopt a strategy that arranges some of the members to break the wind to ensure a lighter wind resistence. In an Olympic Game of TTT, it merely depends on three fastest members among the four participants, while in a Tour de France, known as cycling the whole French country, it depends on the four fastest among the six.

Almost all the famous cyclists are also great time trial athletes simultaneously. At the same time, the ability shown in the time trial is also an important factor to determine the performance of highway team competition. For example, the ability to get out of the riding ability alone, the technology to return to the large group, the ability to catch up with the large group in front due to vehicle failure, and so on.

Besides the road time trial, in other types of bicycle races, there also exist some features of the time trial, such as the mountain bike race and the long-distance cycle race and etc. In a time trial, a young athlete's physical quality, individual techniques and psychological quality.

1.2 Our work

- We define two force curves for the two types of the cyclists, one of them is a specialist in time trials, and the other is a cyclist of different types, also considering the personal information of cyclists.
- We apply our model in different curriculums of various time trials, and include the courses you listed in each power profile defined above: for the 2021 Tokyo Olympics.And also a curriculum we design by ourselves, including at least four sharp turns and at least one important road slope.
- We determine the potential impact of weather conditions, including wind direction and wind strength, to determine how sensitive our results are to small differences in weather and environment.
- We also find the sensitivity of the results to the rider's deviation from the target power distribution. Riders are unlikely to follow a very detailed plan and miss the power target. The rider and sports director will be aware of the possible range of expected segment times for key parts of a given route.

- And we discuss how to extend our model to include the best power use for a team time trial of six drivers per team, where the team's time is determined when the fourth driver crosses the finish line.

2 General assumptions

From the kinematic model, we need to obtain the model of bicycle speed and required power. Before analyzing the entire model, we need to make certain assumptions:

- We don't consider the difference of the participants' techniques and body.

  There are individual differences in players' explosive power, endurance and competition mentality. Only the general situation is considered and individual differences are ignored.

- We don't take the mechanical loss and tire loss into consideration.

  Because the riding distance of individual race is long, with the passage of time, the lubrication of mechanical parts and the wear of tires will cause the change of transmission coefficient. This model ignores the changes of these factors and considers that the mechanical transmission efficiency and tire rolling friction resistance are constant in the whole competition process.

- The mass change of the rider isn't considered.

  With the progress of the race, the loss of body fluid and the depletion of drinking water, the quality will change. This model ignores the changes of these factors and considers that the total mass of riders is constant.

- We don't consider the interaction between participants.

  In the races held before, there existed conditions that while in the home stretch part of the entire track, some of the participants will make mistakes and fell down, which will also affect others' performances, causing others to fall off the bicycle.

3 Lead-in model:Power consumption while cycling

3.1 Variables and constants

The following parameters and variables are used in the calculation of this lead-in model:

Table 1: Variables and constants in the lead-in model

Symbol	Description	Unit
ΣF	Total resistance	N
F_f	Rolling resistance	N
F_g	Gradient resistance	N
F_a	Acceleration resistance	N
F_w	Air resistance	N
P	power	w
v	speed of the bicycle	m/s
e_m	mechanical efficiency of the bicycle	
m	mass of rider and machine	kg
g	acceleration due to gravity	m/s^2
e_r	coefficient of rolling resistance	
a	acceleration of the bicycle	m/s^2
m_w	effective rotational mass of the wheels and the tyres	kg
s	gradient	%
e_D	aerodynamic drag coefficient	
A	frontal area of rider and machine	m^2
ρ	density of air	kg/m^3
v_w	speed of headwind	m/s
δ	angle between bicycle direction and wind direction	rad

3.2 Model construction

There will be some resistance in the process of cycling. We know there are four parts:

- Rolling resistance: the friction between the vehicle and the road will form rolling friction and cause resistance. The rolling friction is the positive pressure multiplied by the friction coefficient, so that:

$$F_f = e_r gm$$

- Gradient resistance: when the vehicle is climbing, the resistance to climbing will be generated due to gravity. Assuming the gradient is , the resistance is:

$$F_g = gmsin(\alpha)$$

- Because the sin value is fixed for a fixed angle, it can be simplified to be expressed as a percentage of the gradient, i.e:

$$F_g = gm \times \frac{s}{100}$$

- Acceleration resistance: when the vehicle is accelerating, the direction of people's force is rotary motion, and then when it is converted to linear motion, there is a certain resistance, which is calculated as follows:

$$F_a = am \times (1 + m_w)$$

- Air resistance: in the process of driving, the vehicle receives air acting on the driving direction to form resistance. The size of the resistance is directly proportional to the square of the speed. When considering the vehicle speed, it is necessary to consider the speed of the wind at the same time. The total moving speed is the sum of the two. Its calculation formula is as follows:

$$F_w = \frac{1}{2} e_D A \rho (v + v_w)^2$$

  In this way, we can get the total force of resistance, but we should also consider the Loss in mechanical energy transmission, we get the equation below:

$$\Sigma F = \frac{1}{e_m}(F_f + F_w + F_g) + F_a$$

$$\Sigma F = \frac{1}{e_m}[e_r gm + gm \times \frac{s}{100} + am \times (1 + m_w)] + \frac{1}{2} e_D A \rho (v + v_w)^2$$

  At last, we calculate the total power through multiplying force and the speed:

$$P = \Sigma F \times v = \frac{v}{e_m}[e_r gm + gm \times \frac{s}{100} + am \times (1 + m_w)] + \frac{1}{2} e_D A \rho (v + v_w)^2$$

$$= \frac{gmv}{e_m}[e_r + \frac{s}{100} + \frac{a}{g}(1 + \frac{m_w}{m})] + \frac{1}{2} e_D A \rho (v + v_w)^2$$

Considering that the object of this model is outdoor cycling. In addition to the factors of riders and vehicles, the power model also needs to consider the factors of site and environment. Therefore, it is necessary to introduce the influence of slope, air resistance, wind force and wind direction. In the actual riding process, with the change of riding direction, the relative angle between wind direction and riding is also changing. The influence of actual wind force is the component of wind force along the riding direction, as shown in the figure below, named as figure 1.

Thus, we can make a supplement to our model:

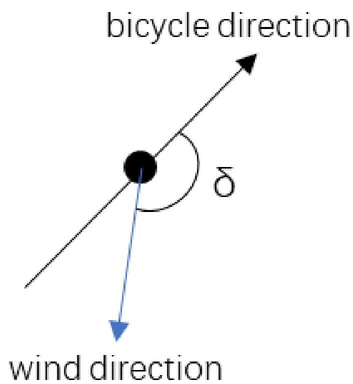

Figure 1: Wind force when riding

$$P = \frac{gmv}{e_m}[e_r + \frac{s}{100} + \frac{a}{g}(1 + \frac{m_w}{m})] + \frac{1}{2}e_D A\rho v(v + v_w cos(\pi - \delta))^2$$

According to the above formula, considering the external factors, we establish the mathematical model of speed, acceleration and power.

4 Model A:Power and speed of turning

In this part, we will consider the condition of bicycles going around the turns, then calculate the power and speed in this circumstance.

The lead-in model is a motion model based on linear motion. In a real race, we also need to consider the driver's steering. We know that a bicycle has two wheels. When turning, the front wheel rotates and the rear wheel does not move. Therefore, we need to calculate the rotation model of the actual vehicle through the attitude and moving speed of the front wheel and rear wheel. We get the demonstrating picture as follows, see figure 2 below[3]:

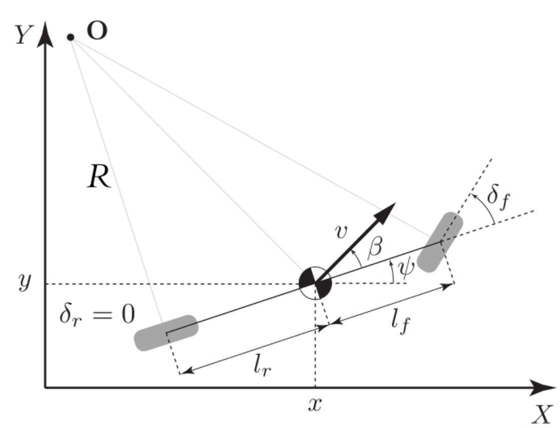

Figure 2: The demonstration picture while turning

4.1 Parameters and variables

In this part, we will list the symbols for the new model in order to demonstrate all the unknowns in the calculation part:

Table 2: Variables and constants of Model A

Symbol	Description	Unit
x	X coordinate of the vehicle	m
y	Y coordinate of the vehicle	m
ψ	The rotating angle of the vehicle	rad
v	The current speed of the vehicle	m/s
l_f	The distance from the front wheel to the bicycle center	m
l_r	The distance from the back wheel to the bicycle center	m
a	Acceleration of the vehicle	m/s^2
δ_f	The rotating angle of the handlebars	rad
t	The current moment/time	s

4.2 Model construction

Based on the symbols and the parameters above, we can get:

$$dx = vcos(\phi_t + \beta)dt$$

$$dy = vsin(\phi_t + \beta)dt$$

It can be obtained from the geometry model that :

$$\frac{l_r}{tan(\beta)} = \frac{l_f+l_r}{tan(\delta_f)}$$

Then we can deduce that:

$$\frac{dy}{dx} = tan[\phi_t + tan^{-1}(\frac{l_r}{l_f+l_r}tan(\delta_f))]$$

It can be seen that the changing rate of position is only related to the current vehicle angle and the steering angle of the rider's handlebar. Therefore, regardless of the speed of the rider when riding, the route of the rider is the same for the same steering direction. For the route of the curve, the angle of the player's control handle has a limit range, usually no more than 30 degrees, in order to successfully turn the curve without falling down. Usually, riders will choose an optimal turning path. When analyzing the optimal turning path, we should first make some assumptions.

4.3 Assumptions

- Regardless of the differences in vehicle performance, weather and road friction, it shall be considered according to the general average level.

  Different road surfaces, slopes, the adjustment effect of bicycles and the wear of tires caused by riding time will lead to the difference of cornering angle and speed. A general model is established to simplify the problem without considering these differences.

- We ignore the level differences of riders and riding strategies and tactics, and turn according to the principle of maximizing speed.

  All competitors always drive into the curve according to the minimum cut to ensure the maximum speed.

4.4 Back to the model construction

Thus, according to our calculation and assumptions listed above, we can succeed in simulating the track and route while the participant is going in a turn, we simulate it in the following way:

- The vehicle travels a very small distance in the direction of the body.
- Take the center of the rear wheel as the origin and draw a circle with radius R. at this time, the intersection with the extension line of the front wheel is the position of the center of the front wheel.
- Repeat steps 1 and 2. After a certain time, fit the center of the rear wheel and the passing position of the center of the front wheel to obtain the steering center, as shown in the following figure, as shown in Figure 3[9]:

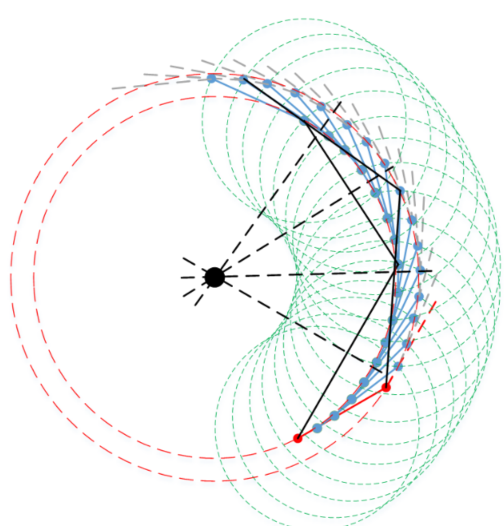

Figure 3: The passing route of the wheels

And then we can list out the equations:

$$tan\delta_f = \frac{l_f+l_r}{R}$$

$$d\phi = \frac{v}{R}dt = \frac{vtan\delta_f}{l_f+l_r}dt$$

Therefore, we know that the angle change rate during cornering is directly proportional to the vehicle speed and steering angle. Therefore, according to the actual curve situation, we can calculate the best turning route and obtain its turning radium R, so as to obtain the best turning angle. At this angle, the faster the speed, the faster the turning speed.

We can gain the best turning radium R through the model below. Assuming that the turning radius r of the curve and the width d of the road are known, the angle from the starting point of the rider to the midpoint of the curve is θ, The following geometric relationships can be constructed, based on the picture drawn below, in figure 4:

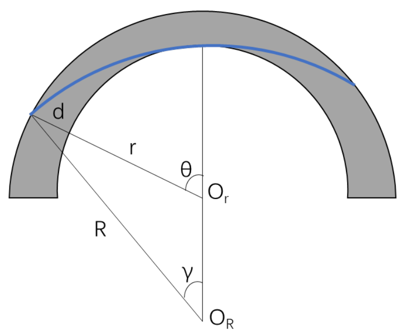

Figure 4: The geometry demonstration figure

The following are the formulas:

$$R^2 = (r+d)^2 + (R-r)^2 - 2(r+d)(R-r) \times cos(\pi - \theta)$$

$$\gamma = cos^{-1}\left(\frac{R^2+(R-r)^2-(r+d)^2}{2R(R-r)}\right)$$

$$l = R \times 2\gamma$$

$$v_{max} = \sqrt{\frac{F_f+F_j}{m}} = \sqrt{\frac{e_r gm+am\times(1+m_w)}{m}} = \sqrt{e_r g + a(1+m_w)}$$

Among all these parameters, r,d,θ are constants and we need to get the R and , then get the distance l the rider actually traveled when passing the curve.

Therefore, when designing the curve, it is necessary to consider the maximum steering angle and the best turning route that the rider can achieve to calculate the maximum speed allowed when the rider turns. The smaller the turning radius is, the lower the maximum speed of the rider when turning the corner. When planning the ride, it is necessary to slow down in advance according to the allowable speed.

5 Model B:Track analyzing and designing

The competition of a fixed length of route needs to be completed in the shortest time. However, each player's body energy has a limit value. At the same time of different power output, the time that can be maintained is also limited. The establishment of this model needs to distinguish the situation of different players.FTP, that is, the average power that a rider can generate in one hour. This value represents the basic ability of riders.The coach also refers to three indicators: 5 seconds, 1 minute and 5 minutes to judge the rider's ability to accelerate in a short time.

5.1 Variables and constants

To enable the deduction of equation, we first list out the variables and constants we use:

Table 3: Variables and constants of Model B

Symbol	Description	Unit
v_t	speed at present time t	m/s
a	acceleration of the bicycle	m^2
t_p	time period of riding	s
S	distance of ride	m
W	work for riding	J

And for the variables in the part track analyzing and designing, we have them in Table 4.

Table 4: Variables and constants in the part track analyzing and designing

Symbol	Description	Unit
S_{up}	Up the hill	m
S_s	A constant pace	m
S_{dn}	Down the hill	m
S_b	The curve	
t_{up}	The remaining time up the hill	s
t_s	The remaining time with a constant pace	s
t_{dn}	The remaining time down the hill	s
i	Totally i up hills	
j	Totally j parts with constant pace	
k	Totally k down hills	
m	With m curves	
v_0	The initial speed in one part of the route	
S	Total distance	m

5.2 Model construction

Firstly, according to physics model, we have:

$$v_t = v_0 + a \times t_p$$

$$S_t = v_0 t + \frac{1}{2} \times a \times t_p^2$$

$$W = P_t \times t_p$$

Based on the former model we have, we can know:

$$\frac{P_t}{m} = \frac{g v_t}{e_m}[e_r + \frac{s}{100} + \frac{a}{g}(1 + \frac{m_w}{m})] + \frac{1}{2} e_D A \rho \frac{v_t}{m}(v_t + v_w cos(\pi - \delta))^2$$

From the web TRAININGPEAKS.COM, and for different riders, take the statistical data and we get:

Table 5: The statistics of different riders

Time(s)	Power per kg(w/kg)	
t_p	$\frac{P_t}{m}$	
	Professional Top Male	Cat3 Top Male
5	22.41	17.51
60	10.81	8.74
300	6.98	5.12
3600	5.87	4.27

From the above table, we can know that there is an upper limit on the continuous output power of each athlete under different sports modes, namely $\frac{P_t}{m} t_p$ exists a maximum amount. The maximum value of the limit acceleration corresponding to different motion modes can be obtained.

Suppose the whole race is divided into several sections:

$$S = \sum_0^i S_{up} + \sum_0^j S_s + \sum_0^k S_{dn} + \sum_0^m S_b$$

$$S(x) = v_0(x) t(x) + \frac{1}{2} a(x) \times t^2(i)$$

Where is the final speed of the previous section, a is the acceleration required by the section, and a does not exceed the maximum acceleration at the current speed when personal physical fitness allows.

5.3 Track analysis of Tokyo Olympics

For this model, only the ideal motion mode for a track is calculated. But not for all athletes, this way of sports is the best. We have designed different models for different types of athletes, determined that different athletes have different force methods, and made slight changes to the model. However, different types of athletes are mainly different in body mass and output power. For athletes with different weights, such as sprint type and climbing type, the data input is different when inputting basic data. At this time, we need to study the upper limit of instantaneous power output of players, such as high output of sprint type and low output of climbing type. We have added a limitation to the designed model, that is, the theoretical output power calculated from the ideal speed and other data should conform to the individual power curve. How to design the power curve here is shown in the types of different riders. In the problem itself, it lists four types of athletes who excel in time trials. In this paper, I'll show you the four types in the following words.

5.3.1 Types of athletes

- Sprinter

  On a flat road, in order to fight against wind resistance, more powerful forces are needed to break the wind resistance, and the faster the breaking speed, the more advantages. Therefore, sprint riders are usually strong and have more muscle volume. Strong muscles are double-sided blades for them, which can show off in the sprint field, but the relative disadvantage is that on the hillside, they will suffer from the gravity generated by gravity on the slope. The sprint type has high output power but heavy weight.

- Climber

  In order to conbat with the gravity itseld, and in order to go on hillsides with a faster speed, the participant himself must have a small weight, which turns out to be the decisive factor in winning the race. Therefore, thin, delicate and small is the common characters of a climber. Some experts have studied that when the slope begins to increase to more than 5%, the muscle will become a kind of resistance due to the relationship of gravity. The muscle is quite heavy. Although a large area of muscle can produce strong force in an instant, it is still far less than the resistance caused by gravity. This is why the standard sprint rider will climb a slope with the same slope and height, You can only see the reason why others behave. Climbing riders can only have a minimum of muscle. Climbers are light in weight, but have low output.

- Rouler

  Roulers belong to the all-round category. They have good abilities in all aspects, but they are slightly inferior to all-round riders. Endurance riders usually play the role of assistant team leader and deputy. They should not only have high stability and strong endurance, but also be good at breaking through the siege and launching attacks actively and actively when necessary. In short, in order to cope with different changes in the war situation, roulers also have to constantly change their positioning, and use their all-round ability to assist the team leaders in fighting and on the road to the championship. They have medium weight and output power. As a result, they will play a great role in the team time trial.

- Puncheur

  Puncheurs, also known as steep sprinters, are good climbers. Their short-range explosive power is their strength. Their slim body shape can enable them to quickly climb the steep top of the mountain, but their disadvantage is their poor endurance. The difference between a puncheur and a pure climber is that a strong rider is good at fighting in rolling hilly terrain, or short and steep hillsides. The powerful short attack is also very suitable for the use of coach tactics. You can use the attack to attract the attention of the opponent's main general, catch the escapee quickly, and even help the team leader win the championship.

5.3.2 The Tokyo Olympics

Here we consider the performance of roulers and sprint players on the Tokyo Olympic track. We will give out the figures below.

The theoretical output power of roulers is as follows, in figure 5:

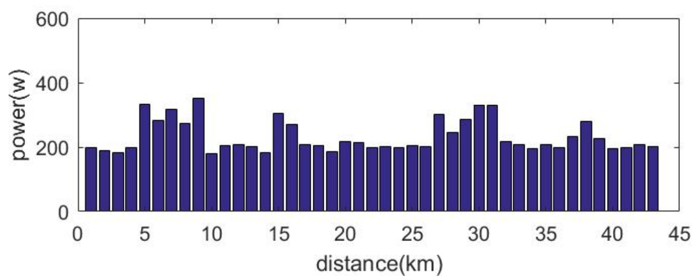

Figure 5: Theoretical output power of roulers in Tokyo Olympic games

The theoretical speed of roulers on the Tokyo Olympic track is as follows, in figure 6:

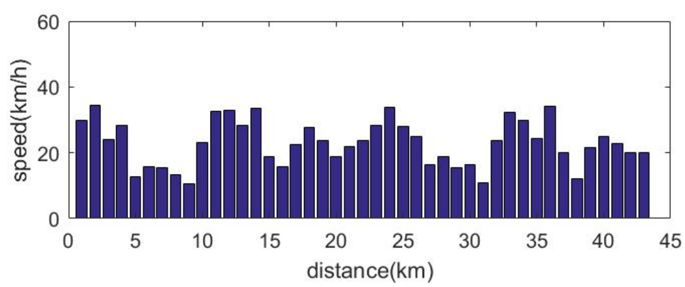

Figure 6: Theoretical speed of roulers on the Tokyo Olympic track

The theoretical output power of sprinters is as follows, in figure 7:

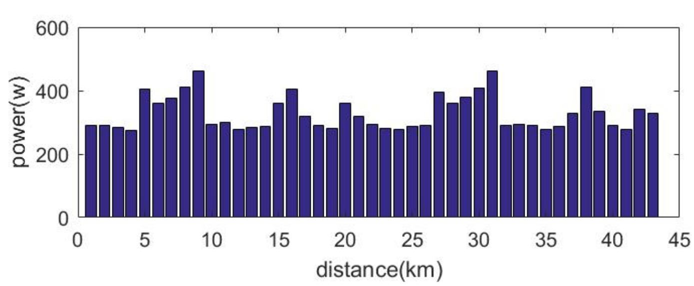

Figure 7: Theoretical output power of sprinters

The theoretical speed of sprinters is as follows, in figure 8:

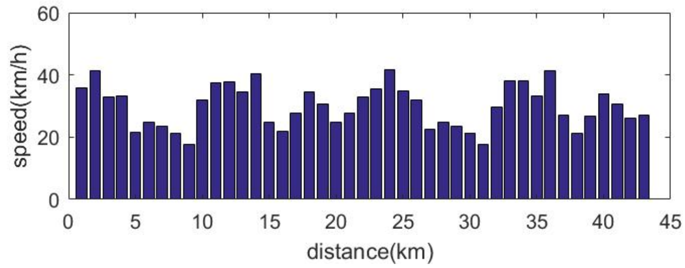

Figure 8: Theoretical speed of sprinters

To make it easier to make comparison between the two circumstances, we respectively attach the two power figures and the two speed figures, as shown below in figure 9 and figure 10.

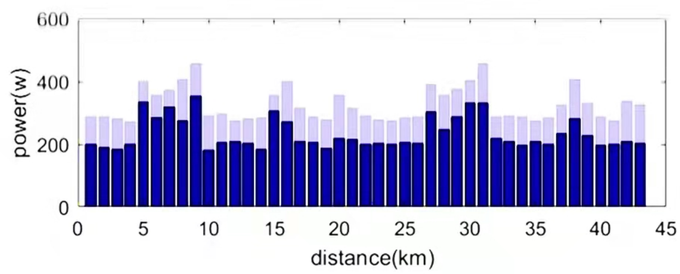

Figure 9: Power comparison

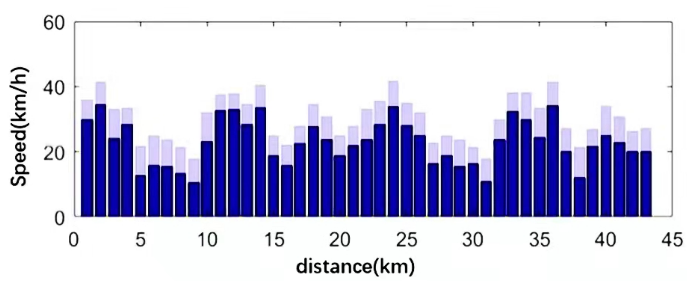

Figure 10: Speed comparison

5.3.3 Personally designed track

Our personally designed track consists of some curves and some straight tracks, it applies the third advance of the model. This track is on the road around Taihu Lake. The circular road around Taihu Lake is the first scenic road of inter provincial cooperation in China. Wherever you are on the road, you can get great services. Furthermore, there are many post kiosks along the road which can offer you help during your ride. Since the horizontal plane is nearly the same, we can just pay a little attention to the transformation of altitude. We will show you our own designed track in figure 11 and the altitude change in figure 12 below:

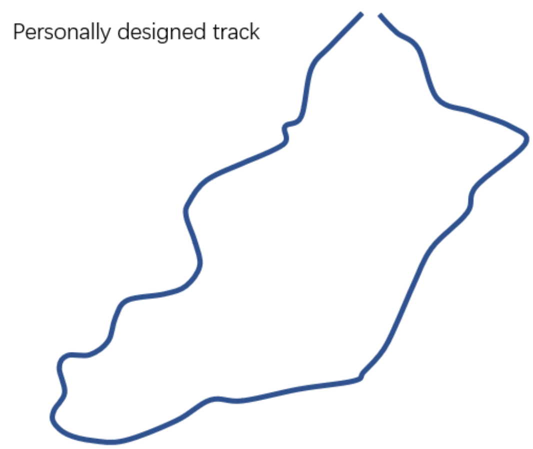

Figure 11: Our track

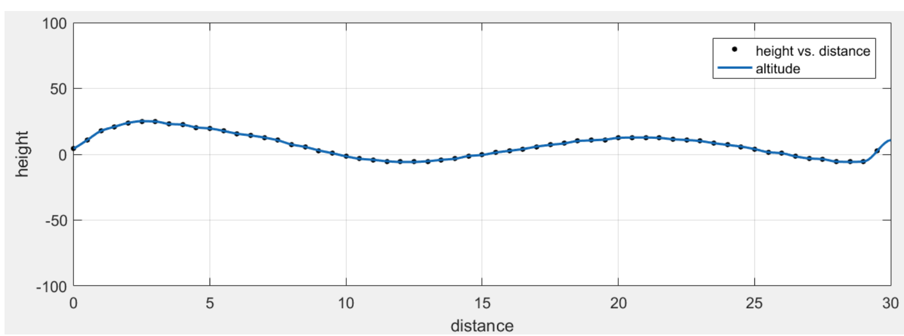

Figure 12: Altitude change in our track

The calculation method is the same as that of model constructed above, except that the speed limit of curve is added.

According to the model, when the speed reaches a certain value, you can't cut into the curve with large central angle. Therefore, we add the calculation of curve to the speed limit here. Here is an example of a sprinter.

The following is the speed limit of the curve, in figure 13.

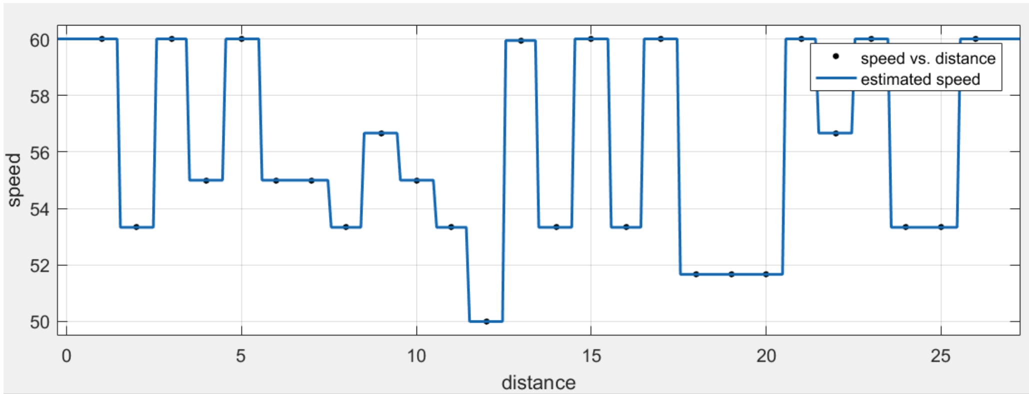

Figure 13: The speed limit of a sprinter

After adding the above requirements, the speed is as follows, in figure 14:

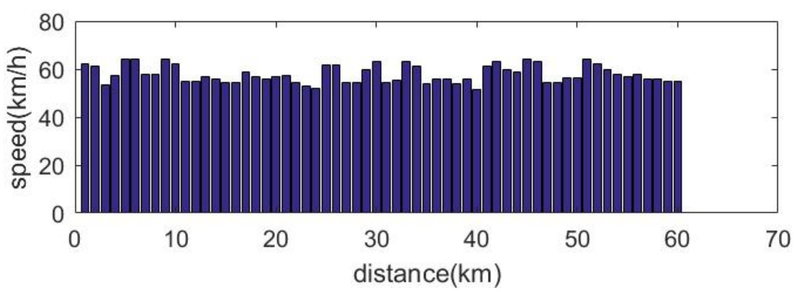

Figure 14: Speed after adding the above requirements

6 Supplementary model: A Team Time Trial

In TTT, the team cooperation between players is tested. In order to reduce the wind resistance suffered by some players, one person will usually rush to the front to break the wind for his teammates, so as to reduce the power of the players behind. But this is not permanent. Generally speaking, the first rider will choose to ride for a period of time and then change to the last, and so on. Because in the TTT competition, only the top four results are selected, so a windbreaker will be arranged to shield his teammates from the wind for less time, so that he can finish the sprint at the end. Therefore, TTT tests team cooperation more than ITT, rather than individual sprint.

The multiplayer program design is the same as before, except that the wind resistance of six people is reduced to 1.5 people. At this time, every corner changes the person who breaks the wind in the front. The self-designed track is still used here.

In addition, the speed limit is the same as above, shown in figure 15:

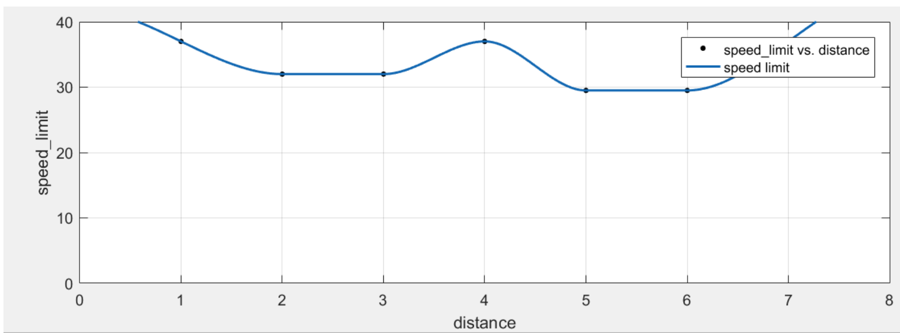

Figure 15: The speed limit

Under the speed limit, the speed of each contestant shall be the same as the ideal speed. The power is not proportional to the speed because the wind resistance is different. Figure 16 below shows the ideal power of a single person.

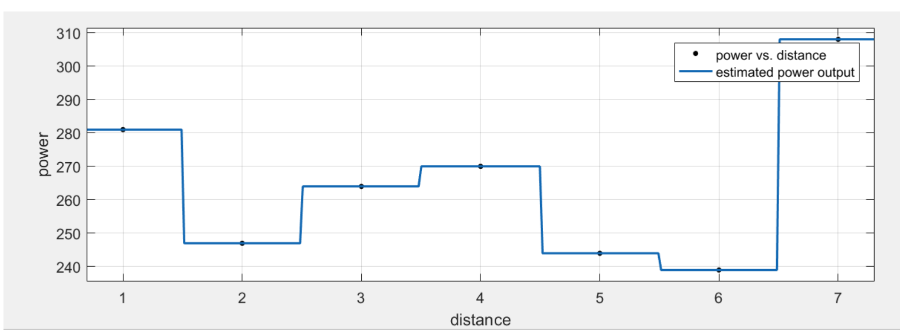

Figure 16: The ideal power of a single person

In each time period, six players will take the lead, and the last two players who sacrifice will bear the wind breaking of the countdown distance of 1 to 2.5 and 2.5 to 4 respectively. Therefore, in general, the individual power curve will become smaller due to different individual abilities and the reduction of a large part of the wind resistance, but the wind resistance will increase sharply in the section where the individual breaks the wind resistance.

7 Sensitivity analysis

Sensitivity analysis is a method to study and analyze the sensitivity of the state or output change of a model to system variables. In optimization methods, sensitivity analysis is often used to study the stability of the optimal solution when the original data are inaccurate or changed. Sensitivity analysis can also determine which parameters have a great impact on the system or model.

After changing the speed according to a certain proportion, study its impact on the completion time. In this way, we can study the impact of deviation from the ideal speed on the final result. We multiply the theoretical optimal speed of each stage by the corresponding coefficient to calculate the new completion time. After the coefficient finish time image is obtained, we can analyze the impact of deviation as a whole. As shown in the figure, the completion time decreases with the increase of speed and increases with the decrease of speed. The reality is that if the speed exceeds the limited threshold, it will be difficult to continue the race after that. The result is shown in figure 17 below:

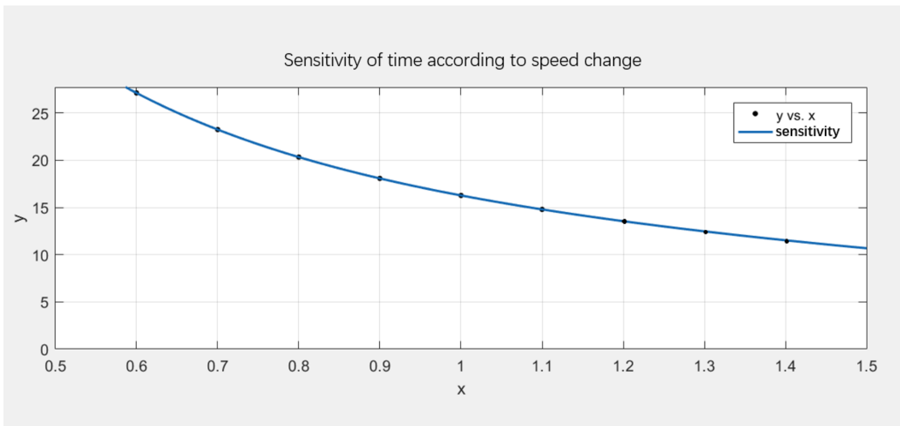

Figure 17: Sensitivity of time according to speed change

The actual impact is shown in this figure. The influence of aftereffect is considered in further calculation. The actual result is shown in figure 18 below:

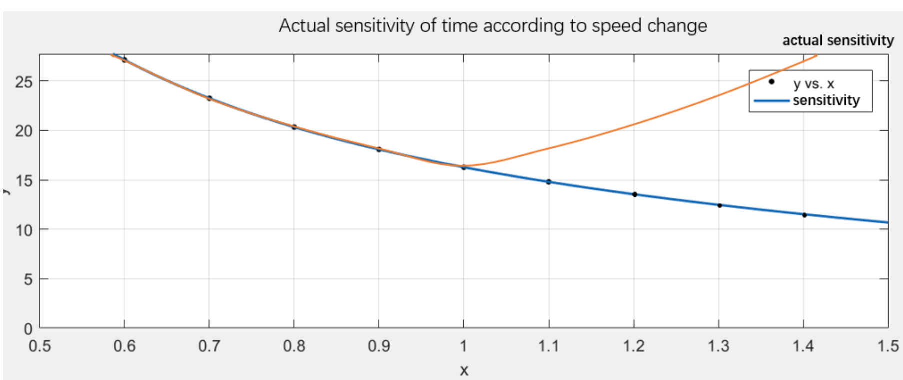

Figure 18: Actual sensitivity of time according to speed change

Therefore, only when the optimal speed is met, the time consumption is the least.

In addition, there are different constants in the formula that need sensitivity analysis. After sensitivity analysis, the indexes are within a reasonable range.

8 Strengths and weaknesses

8.1 Strengths

- Effectiveness

  Our model effectively designs a racing course that can be applied to all types of cyclists. We divided the course into several parts and found the best combination of the parts to put them into a whole course.

- Comprehensiveness

  We considered many factors that may affect the power of the cyclists, such as the rolling resistance, grade resistance, air resistance and etc. Therefore our model gives a relatively precise solution to the problem.

8.2 Weaknesses

- We just do a little work on the part "Supplementary Model: A Team Time Trial"

  Mentioned above in the supplementary, we initially consider the part of the race TTT, namely Team Time Trial, but we just analyze a little of it while giving out some figures, if we have time, we will try to complete the modeling and calculation of this part, as the model of breaking wind and rotating is really worth trying.

9 A riders' guide for the team director

Hello, cyclist director.

Your cyclists are welcomed to this competition on our scientifically designed course.

Due to the diversity of the competition our course will hold, we designed a course which can be appropriate for any type of competitors. Whether you are a professional or an amateur, you are warmly welcomed to ride and compete on our racing course.

Our racing course consists of several twists and turns, and there are a few places where the altitude changes. Since the course has just been designed, and it is new to you, there are a few suggestions we can give that may help your riders in your bike competition.

Before the competition starts, your cyclists are not to practice too hard, and remember to make full preparation for your competition. Take whatever you need, but don't take too much. Heavy burden may reduce your speed and draw your energy out of your body.

Choose a best bike as well. Choose a bike that may be easy to climb and have a strong grip on the ground to reduce your speed quickly.

Be confident when your participants compete. The riders' attitude may also affect your chance of winning. Let them not be disappointed if one of them rode a little bit slower than the other riders. They may do better in the later competition. Just keep their most comfortable pace and ride on, for our course suits all kinds of riders. Don't pay too much attention on the rivals, instead, concentrate on the track.

It may be hard for cyclists to climb the mountains, and the highest point of our course is near the end. So be careful when the riders make effort to climb and ride on flat roads, for they may use up all their power before reaching the finishing line, and it could be very hard for them to sprint when their energy is nearly used up.

You may also let them try to save their power when on a downhill track. There are a few of them and make sure your participants make good use of it.

In order to keep up going, your riders should supply consumption of energy in time. Your cyclists may bring some energy gels with them as well. Replenishing energy on our way is essential for their chancec of winning.

For the several turns in our course, tell them that they ought to be aware of the limited speed, and make sure their own speed is not higher than the highest limited speed. Otherwise, they might rollover.

Also, pay attention to the weather. Though the direction of the wind may not count much in their speed, it may still play an import part deciding whether they are going to win or not.

If the weather on the day of competition is rainy or snowy, remember to be careful on the course, the course would be more slippery and easier to fall over, be especially careful when they make their turns.

For our team races, you may ask them to have one leader who rides in the front to help others reduce wind resistance. Our advice is that they should change your leader in every turn, for it may provide the best bet in winning your competition. In the sprints, the two riders who helped to reduce the most wind resistance for their teammates may stop for a rest and give hope to your teammates.

If they don't achieve an ideal ranking in the competition, don't blame them or their teammates. Just get relaxed and treat the competition as a meaningful memory.

In the end, we wish your team members all achieve ideal results in the competition and may them a great competition experience!

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