MATH
数模加油站

美赛冲O/F奖的八大套路

史上最全数学建模综合教程（数学建模写作、算法、编程从入门、速成到进阶）

学会模仿|学会包装

主讲人：江北

O/F套路 | 八大套路技巧

美赛获O/F奖的套路

1、学会模仿：模仿O奖论文

2、选好题目：选择最适合你们的题目

3、写好标题：适当地生动一些

4、着重摘要：美赛初评主要看摘要的质量

5、模型建立求解：模型要结合问题，算法要有优越性

6、分析到位：得出结果必须对结果进行详细的分析

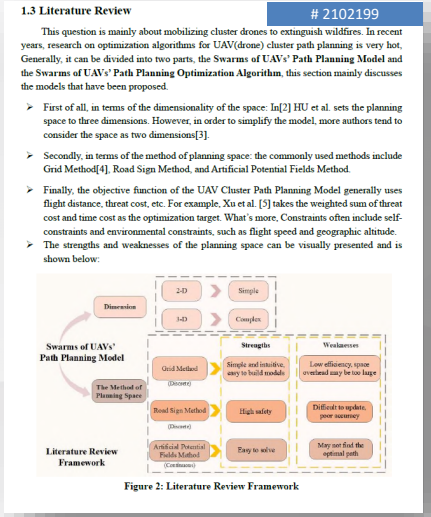
7、灵敏度分析：结合图表，有图有分析

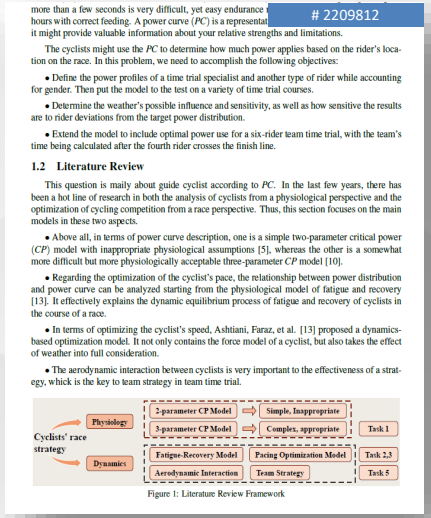
8、学会包装：美化绘图，做好排版

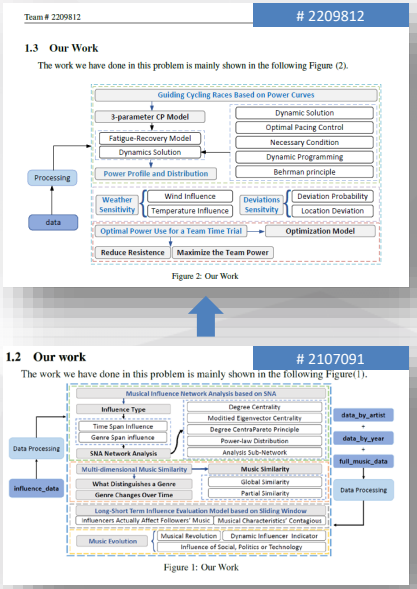
O/F套路 | 1. 模仿O奖论文

➢ 模仿O奖论文

- 绝大部分O奖论文都有极为相似的套路和格式，各个部分该怎么写，不能怎么写，包括论文长度，绘图等细节，都能从O奖论文学习得到。所以大家一定要多看历年优秀论文，特别是20年后的，找他们的共同之处进行模仿。







关注公众号：【数模加油站】，免费领取更多数模相关资料

O/F套路 | 2. 选好题目

➢ 选择合适的题目

- 最初的的选题和分析是大家最头疼的事情，选题选的不好，直接导致做不下去。在这种情况下，无论是选择随大流，还是想着选选的人少的题目去博一个奖都是不合适的，还是要坚定的对比选择最适合最擅长的题目类型，每个题目都有O/F奖和冠名奖。

MCM		ICM	
A	连续型	D	运筹学
B	离散型	E	可持续性
C	大数据	F	政策

PS：选完题目之后不到穷途末路千万不要换题，浪费时间且影响心态。没有人看完题目就有非常成熟的解决思路，大家在做题的过程中总会遇到很多不理解或者难以进行的地方，这个时候如果发现网上也没特别好的解决办法，那就可以对题目中不理解或难以实现的点大胆假设，不要想实际最复杂的情况，要想怎样假设自己能解决，只要合理，是不会影响你得O奖的（19年养龙O奖论文就假设龙为圆柱体进行计算）

O/F套路 | 3. 写好标题

➢ 写好论文标题

- 两段式：Crack the Wordle Puzzle: Word Attribute Analysis Approaches（破解 Wordle 之谜：词语属性分析方法）
- 常规的：Viral Spread Characteristics and Difficulty Determinants of Wordle Modeling Based on Differential Equations and K-nearest Neighbors（基于……方法的……研究）
- 有吸引力的：Uncover the Hidden Secrets in Wordle Results（揭开 Wordle 结果中隐藏的秘密）
- 简约的：Winners in Wordle（Wordle 中的获奖者）

在美赛历年优秀（O奖）论文中，用常规标题的相对较少，多数质量较高的论文都选择了其他几种更有吸引力的标题，让评委觉得这篇文章很有趣，想读下去。

- 2023A题O奖标题：

  Community Succession Simulation: Surviving Drought（社区继承模拟： 在干旱中生存）

  Dry or Die? Drought-Stricken Plant Communities Can Survive!（干旱还是死亡？干旱植物群落也能生存）

  TheWarriors against Drought: Plant Communities（抗旱勇士 植物群落）

O/F套路 | 4. 着重摘要

➢ 着重摘要

- 摘要在国赛和美赛中重要程度已经反复提过很多次了，一定是重中之重，获奖论文通常会根据摘要的质量与其他论文区分开来（美赛官网描述）。建议对照往年优秀论文来写摘要，优秀论文的模型算法学不来，摘要还是一定要学的。

常用模板

开头段：针对什么问题，建立了什么模型

针对问题一，建立的模型+求解的过程+得到的数值+意义

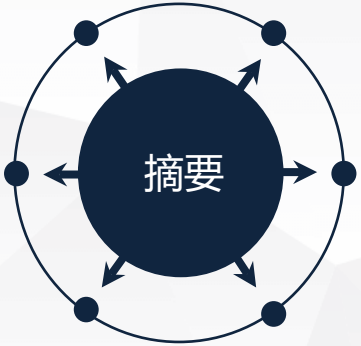
针对问题二，……

针对问题三，……

结尾总结段：模型的优缺点，灵敏度分析等，以及可以改进的方面（非必要）

模型名称，算法名称，关键变量，模型结果常常要加粗

注意摘要页控制在一页内

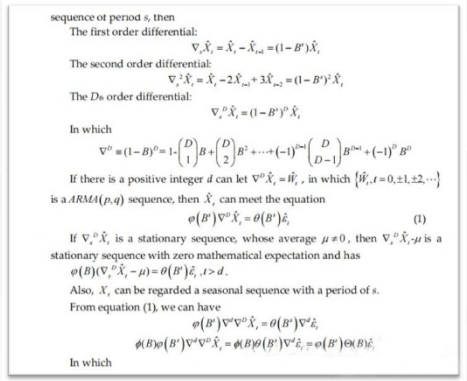


注意：
模型算法的专有名词不能错，每一小问，都要给一个明确的结果（数值或文字描述），每一个关键模型，都要结合题目去描述如何设置参数和求解，但整体语言必须力求不影响读者理解的前提下，越精练越好。若摘要写的逻辑混乱、评委找不到模型和每一问的求解结果，就与获奖无缘。

O/F套路 | 5. 模型建立与求解

➢ 优秀的模型具有什么样的特点

- 模型都是可以简单的，可以不用那么复杂，但要考虑全面
- 查阅文献，结合现有模型或自制创新想法的模型
- 一般后续的问题是能用上前面问题建立的模型的
- 不要一味追求高级算法，比如硬套神经网络，无脑用智能算法
- 模型刚开始可以先不考虑那么复杂，随着问题逐步递进
- 模型描述必须具体，必须结合你的具体问题来描述分析



sequence of period s, then

The first order differential:

$$\nabla_s \hat{X}_t = \hat{X}_t - \hat{X}_{t-s} = (1-B^s)\hat{X}_t$$

The second order differential:

$$\nabla_s^2 \hat{X}_t = \hat{X}_t - 2\hat{X}_{t-s} + 3\hat{X}_{t-2s} = (1-B^s)^2 \hat{X}_t$$

The D_n order differential:

$$\nabla_s^D \hat{X}_t = (1-B^s)^D \hat{X}_t$$

In which

$$\nabla^D = (1-B)^D = 1 - \binom{D}{1}B + \binom{D}{2}B^2 + \cdots + (-1)^{D-1}\binom{D}{D-1}B^{D-1} + (-1)^D B^D$$

If there is a positive integer d can let $\nabla^D \hat{X}_t = \hat{W}_t$, in which $\{\hat{W}_t, t = 0, \pm 1, \pm 2, \cdots\}$ is a $ARMA(p,q)$ sequence, then $\hat{X}_t$ can meet the equation

$$\varphi(B^s)\nabla^D \hat{X}_t = \theta(B^s)\hat{\varepsilon}_t \qquad (1)$$

If $\nabla_s^D \hat{X}_t$ is a stationary sequence, whose average $\mu \neq 0$, then $\nabla_s^D \hat{X}_t - \mu$ is a stationary sequence with zero mathematical expectation and has

$$\varphi(B)(\nabla_s^D \hat{X}_t - \mu) = \theta(B^s)\hat{\varepsilon}_t, t > d.$$

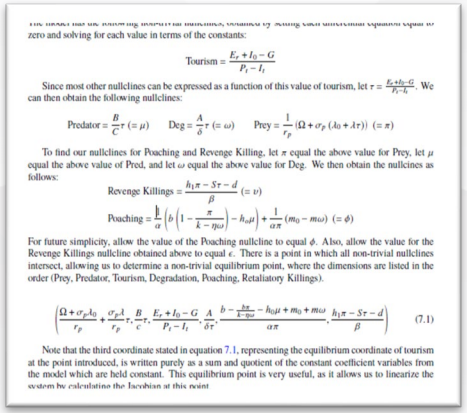
Also, X_t can be regarded a seasonal sequence with a period of s.

From equation (1), we can have

$$\varphi(B^s)\nabla^d \nabla^D \hat{X}_t = \theta(B^s)\nabla^d \hat{\varepsilon}_t$$

$$\phi(B)\varphi(B^s)\nabla^d \nabla^D \hat{X}_t = \phi(B)\theta(B^s)\nabla^d \hat{\varepsilon}_t = \varphi(B^s)\Theta(B)\hat{\varepsilon}_t$$

In which



zero and solving for each value in terms of the constants:

$$\text{Tourism} = \frac{E_t + I_0 - G}{P_t - I_t}$$

Since most other nullclines can be expressed as a function of this value of tourism, let $\tau = \frac{E_t + I_0 - G}{P_t - I_t}$. We can then obtain the following nullclines:

$$\text{Predator} = \frac{B}{C}\tau \ (= \mu) \qquad \text{Deg} = \frac{A}{\delta}\tau \ (= \omega) \qquad \text{Prey} = \frac{1}{r_p}(\Omega + \sigma_p(\lambda_0 + \lambda\tau)) \ (= \pi)$$

To find our nullclines for Poaching and Revenge Killing, let π equal the above value for Prey, let μ equal the above value of Pred, and let ω equal the above value for Deg. We then obtain the nullcines as follows:

$$\text{Revenge Killings} = \frac{h_1\pi - S\tau - d}{\beta} \ (= \upsilon)$$

$$\text{Poaching} = \frac{h}{\alpha}\left(b\left(1 - \frac{\pi}{k - \eta\omega}\right) - h_0\mu\right) + \frac{1}{\alpha\pi}(m_0 - m\omega) \ (= \phi)$$

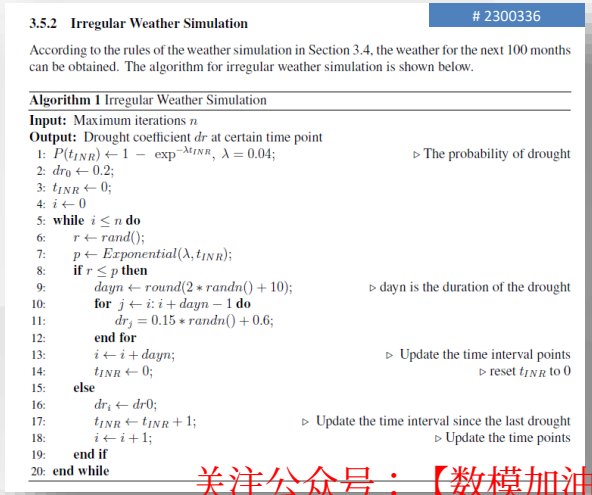
For future simplicity, allow the value of the Poaching nullcline to equal ϕ. Also, allow the value for the Revenge Killings nullcline obtained above to equal ϵ. There is a point in which all non-trivial nullclines intersect, allowing us to determine a non-trivial equilibrium point, where the dimensions are listed in the order (Prey, Predator, Tourism, Degradation, Poaching, Retaliatory Killings).

$$\left(\frac{\Omega + \sigma_p\lambda_0}{r_p} + \frac{\sigma_p\lambda}{r_p}\tau, \frac{B}{C}\tau, \frac{E_t + I_0 - G}{P_t - I_t}, \frac{A}{\delta}\tau, \frac{b - \frac{b\pi}{k - \eta\omega} - h_0\mu + m_0 + m\omega}{\alpha\pi}, \frac{h_1\pi - S\tau - d}{\beta}\right) \qquad (7.1)$$

Note that the third coordinate stated in equation 7.1, representing the equilibrium coordinate of tourism at the point introduced, is written purely as a sum and quotient of the constant coefficient variables from the model which are held constant. This equilibrium point is very useful, as it allows us to linearize the system by calculating the Jacobian at this point.

➢ 求解的算法

- 算法的目的是为了求解模型，是模型的重要组成部分，美赛相比于国赛，对于算法的创新程度更加看重。
- 对于美赛而言，好的算法可以直接提高模型和答卷的质量。所以编程手能够把算法的优越性表达给论文手，才能把算法写出彩，要结合你的题目内容把这个算法的求解的过程写清楚（可以考虑多模型对比体现优越性）。部分算法可以再文章里放一些伪代码。



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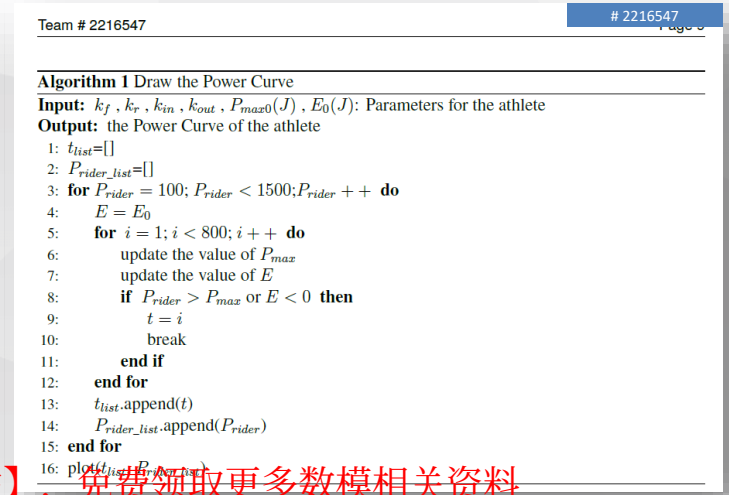
3.5.2 Irregular Weather Simulation

According to the rules of the weather simulation in Section 3.4, the weather for the next 100 months can be obtained. The algorithm for irregular weather simulation is shown below.

Algorithm 1 Irregular Weather Simulation

Input: Maximum iterations n
Output: Drought coefficient dr at certain time point

$P(t_{INR}) \leftarrow 1 - \exp^{-\lambda t_{INR}}$, $\lambda = 0.04$; ▷ The probability of drought
$dr_0 \leftarrow 0.2$;
$t_{INR} \leftarrow 0$;
$i \leftarrow 0$
while $i \leq n$ **do**
  $r \leftarrow rand()$;
  $p \leftarrow Exponential(\lambda, t_{INR})$;
  if $r \leq p$ **then**
    $dayn \leftarrow round(2 * randn() + 10)$; ▷ dayn is the duration of the drought
    for $j \leftarrow i : i + dayn - 1$ **do**
      $dr_j = 0.15 * randn() + 0.6$;
    end for
    $i \leftarrow i + dayn$; ▷ Update the time interval points
    $t_{INR} \leftarrow 0$; ▷ reset t_{INR} to 0
  else
    $dr_i \leftarrow dr0$;
    $t_{INR} \leftarrow t_{INR} + 1$; ▷ Update the time interval since the last drought
    $i \leftarrow i + 1$; ▷ Update the time points
  end if
end while



Team # 2216547

2216547

Algorithm 1 Draw the Power Curve

Input: k_f , k_r , k_{in} , k_{out} , $P_{max0}(J)$, $E_0(J)$: Parameters for the athlete
Output: the Power Curve of the athlete

t_{list}=[]
P_{rider_list}=[]
for $P_{rider} = 100$; $P_{rider} < 1500$;$P_{rider}++$ **do**
  $E = E_0$
  for $i = 1; i < 800; i++$ **do**
    update the value of P_{max}
    update the value of E
    if $P_{rider} > P_{max}$ or $E < 0$ **then**
      $t = i$
      break
    end if
  end for
  t_{list}.append(t)
  P_{rider_list}.append(P_{rider})
end for
plot(t_{list},P_{rider_list})

➢ 结果分析

- 结果分析一定一定要到位，所有优秀论文都逃不出一个共性，就是分析到位。这听上去很简单，不过能将这点做好的人并不多，很多人就是放个图放个数据就结束了。
- 老师看到一张结果图的时候，他是看不明白的。这时候你一定要把你的分析写在结果图的上下，而且越多越详细越好。千万不要只有一张图和一行分析就了事了，此是论文大忌。

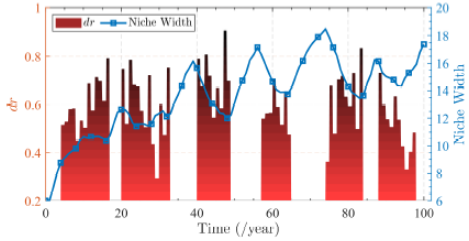


Figure 13: Variation of drought coefficient dr and niche width over time

As shown in Figure 13, it can be seen that when no drought occurred, the total niche width of the community showed an increasing trend. This indicates that the environment is suitable for the growth of plants and the population reproduces more at this time. However, when drought occurred, the total niche width showed a decreasing trend. Besides, the more severe the drought, i.e., the greater the dr, the faster the total niche width decreases. It demonstrates that drought inhibits the reproduction of the population and the inhibitory effect increases as the degree of drought increases.

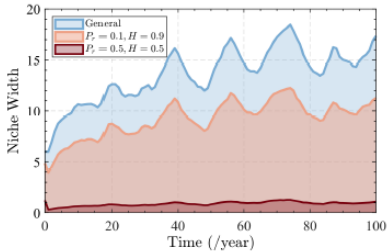


Figure 17: Evolution of plant communities facing pollution and shrinking habitats

As shown in Figure 17, the community ecological niche width is relatively reduced when pollution is light and habitat reduction is less. At this time, the plant community is still able to survive stably for a long time. When the pollution is heavy and the habitat is reduced more, the ecological niche width is close to 0, that is, many species in the community will become extinct at this time.

O/F套路 | 7. 灵敏度分析

➢ 灵敏度分析

- 灵敏性分析一般在论文结尾，是绝对的加分项，最好需要有图有分析。此外还有模型检验、误差分析、有效性分析、鲁棒性分析、适用条件分析、横纵向对比等。
- 灵敏度分析要结合文字进行解释说明，不要为了灵敏度分析而分析，要说明为什么对某个参数做灵敏度分析，通过结果可以说明什么？

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9 Sensitivity Analysis

The growth rate is an important parameter in our model. In order to explore the impact of growth rate change on population density, we changed the growth rate of eight populations within the deviation range of -5% to 5% to obtain population densities. The results are shown as follows:

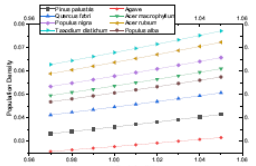

Figure 17: Sensivity Analysis of r

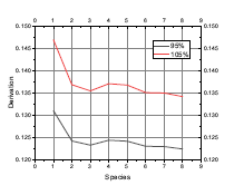

Figure 18: The Rationship between Species and Derivation

Observing the left graph, it can be seen that as r increases, the population density of each species in steady state also increases. The right graph shows the relationship between deviation and species diversity. Species 1-8 are Pinus palustris, Agave, Quercus favri, Acer macrophyllum, Populus nigra, Acer rubrum, Taxodium distichum, and Populus alba, respectively.

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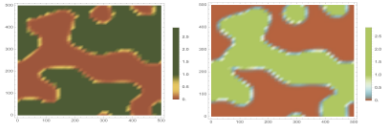
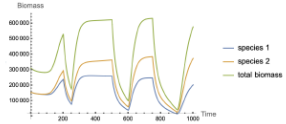
and resistance. Resilience is defined as the ability of a plant as a species that is, its ability to reproduce to return to its previous biomass. Resistance is defined as the ability of individual plants within a species to survive environmental stress

Thus, we can use the growth rate parameter c_i as a proxy to measure the impact of plant species resilience. Specifically, recalling a baseline value of $c_i = 1$, we investigate two cases: $c_i = 0.8$, where plants are less resilient, and $c_i = 1.2$, where plants are more resilient.



(a) **Species 1 of 2 with $c = 0.8$.** (b) **Species 2 of 2 with $c = 0.8$.**



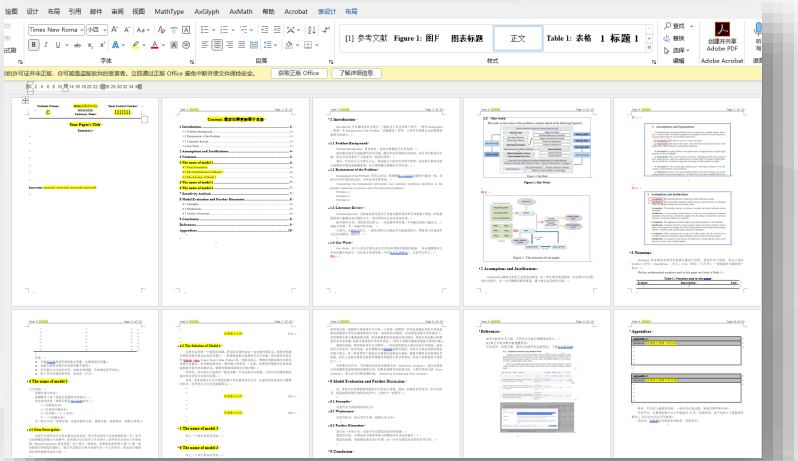
(c) **Biomass over time with $c = 0.8$.**

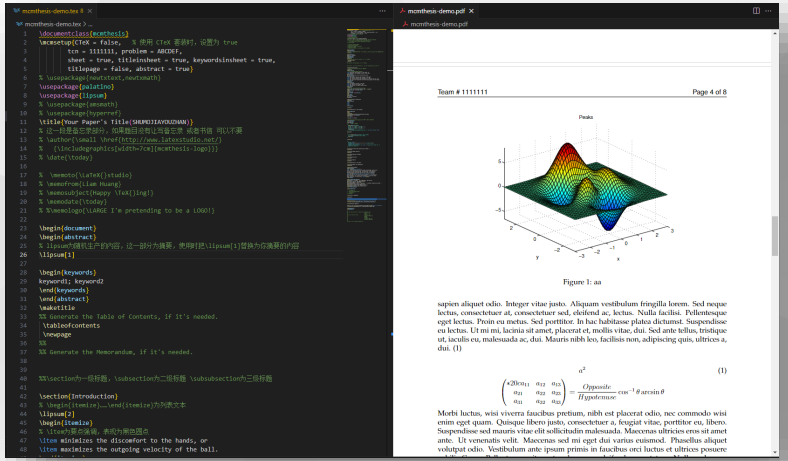
Figure 11: **A two-plant community with lower resilience levels.** All snapshots are taken at $t = 1000$.

O/F套路 | 8. 学会包装

➢ 做好排版

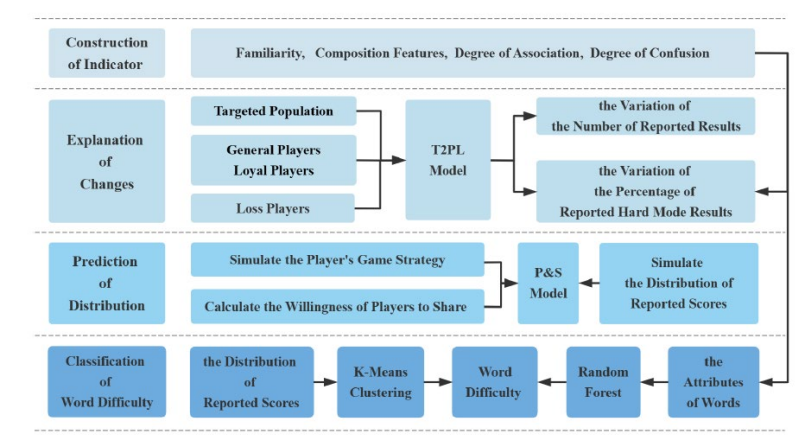
- 在美赛中，完美的排版是高分的基础，推荐利用Latex进行排版，当然Word一样能排版出不亚于Latex的效果，这里大家可以免费领取美赛的Latex及Word模板，只要学会使用模板，论文排版还是比较简单的。

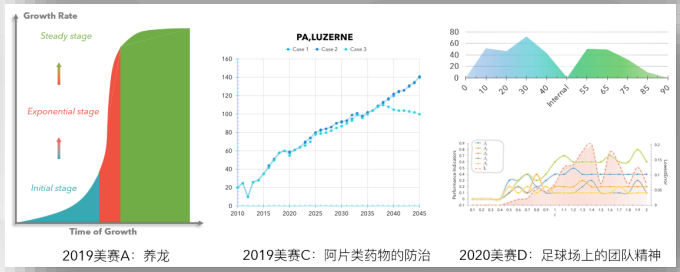




➢ 好看的图片

- 如何抓住老师的眼球，主要靠图像！在问题分析时用思维导图展示你的思考过程，算法绘制流程图，结果曲线图的美化等等。多看美赛0奖论文，学习里面的图表表现方式，不说理解所有图片的内容，但最起码看到近几年0奖论文的图片，你要知道如何模仿和复现。





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THANKS