| Problem Chosen | 2025 | Team Control Number |
|:---:|:---:|:---:|
| **C** | **MCM/ICM**<br>**Summary Sheet** | 2506135 |

# Together, Individuals Make a Difference

### Summary

Here is the abstract of your paper.

Firstly, that is ...

Secondly, that is ...

Finally, that is ...

$F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-i\omega t}\,dt$

$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega)e^{i\omega t}\,d\omega$

**PCA**


**Keywords**:  **A, B, C,**

# Contents

# 1    Introduction

## 1.1    Problem Background

During the 2024 Paris Summer Olympics, fans not only paid attention to the individual events but also showed significant interest in the the ranking of countries on the overall medal count and gold medal table. Ultimately, the United States topped the medal table with a total of 126 medals, while China and the United States shared the top position on the gold medal table, each securing 40 golds. The host country, France, ranked fifth on the gold medal table with 16 gold medals, but finished fourth in the total medal count. Great Britain ranked seventh on the gold medal table with 14 golds, while securing third place in the overall medal count. Despite the prominence of the leading countries, the medal achievements of other nations also attracted attention. For example, Albania, Cape Verde, Dominica, and Saint Lucia each won their first-ever Olympic medal in this edition of the Games, with Dominica and Saint Lucia each earning another gold medal. However, over 60 countries have yet to win a medal in the history of the Olympics.

## 1.2    Restatement of Problem

While predictions of the final medal counts at the Olympics are common, such forecasts are generally not based on historical medal tables. Instead, they are typically made before the start of the upcoming Olympic Games, once the list of competing athletes is known.To clarify the task, the problem is restated as follows:

- Develop a model for each country's medal count, which should at least include the number of gold medals and the total medal count, and estimate the uncertainty/precision of the model,also evaluate its performance.

    1) Using the model, predict the medal standings for the 2028 Los Angeles Summer Olympics, including prediction intervals for all outcomes. Based on the model's predictions, identify which countries are most likely to improve their performance and which countries are expected to perform worse than in the 2024.

    2) The developed model should include countries that have not yet won any medals, while also predicting the number of countries likely to win their first medal in the upcoming Olympics and provide odds for this estimate.

    3) The model should also consider the number and types of events in each specific Olympic Games, exploring the relationship between the events and the number of medals won by each country. For each country, determine which events are most crucial and why, as well as the impact of the country's selected events on the results.

- In contrast to athletes, who must change their citizenship in order to represent different countries in competitions, coaches do not need to change their citizenship to coach, which makes it easier for them to move to other countries. As a result, the "Great Coach" effect may arise. For example, Lang Ping has coached the volleyball teams of both China and the U.S., leading both to championships, while Bela Karolyi coached the Romanian and U.S. women's

gymnastics teams, achieving great success. The task is to identify evidence in the data that may suggest changes driven by the "Great Coach" effect and estimate its impact on the medal count. Select three countries, determine the events in which they should consider investing in "outstanding" coaches, and estimate the potential impact of such investments.

- Explain the unique insights regarding Olympic medal counts that are included in the developed model and how these insights can provide valuable information to the National Olympic Committees of various countries.

## 1.3　Our work

We do such things ...

1. We do ...

2. We do ...

3. We do ...

# 2　Question Preparation

## 2.1　Assumptions

## 2.2　Notations

The primary notations used in this paper are listed in Table 1.

# 3　Data Preprocessing

## 3.1　Basic Data Preprocessing

$$G_i \cap G_j = \emptyset, \bigcup_{i=1}^{5} G_i = X \tag{1}$$

Table 1: Notations

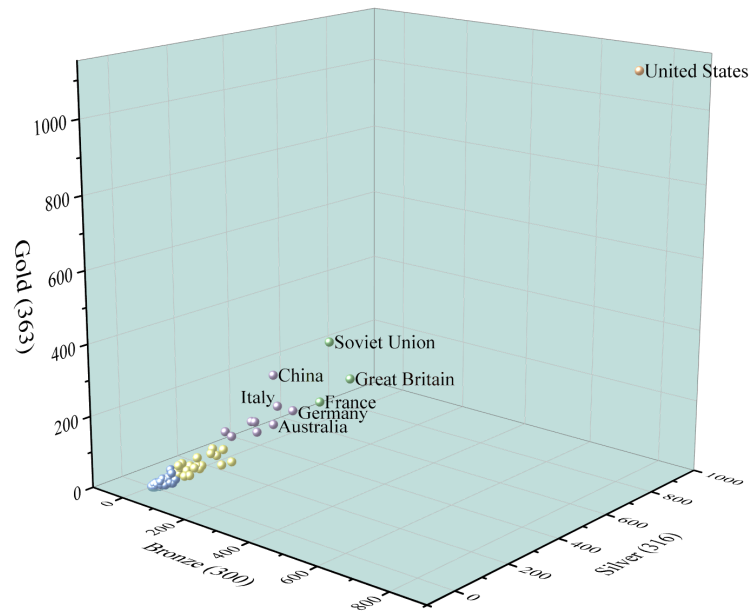| Symbol | Definition |
|---|---|
| $C_i$ | the first one |
| $S_i$ | the second one |
| $G$ | the second one |
| $V$ | the second one |
| $B$ | the second one |
| $M$ | the second one |
| $A$ | the second one |
| $D$ | the second one |
| $E$ | the second one |
| $\gamma$ | Sport Advantagen Coefficient |
| $m_{c_i}$ | the second one |
| $m_{c_i s_j}$ | the second one |
| $g_i$ | the second one |
| $\xi$ | The Probability of First Medal |



Figure 1: Scatter plot of national level classification (based on Kmeans++clustering algorithm)
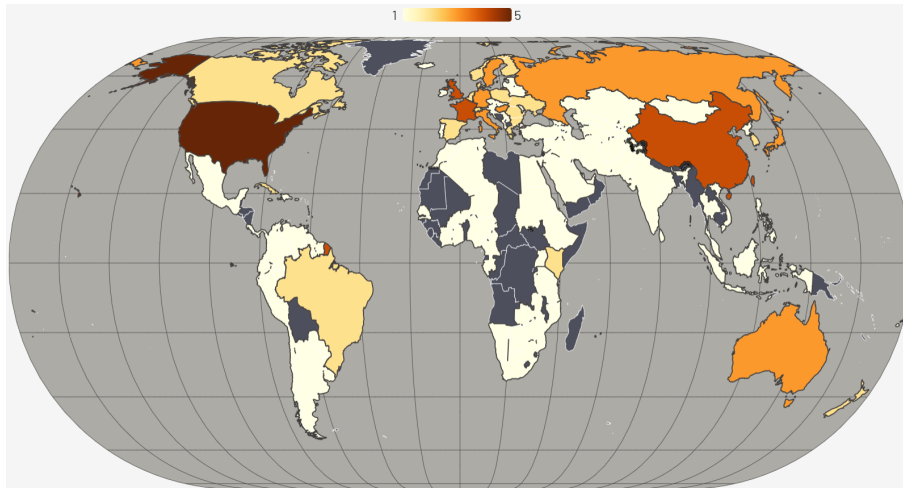
Figure 2: aa
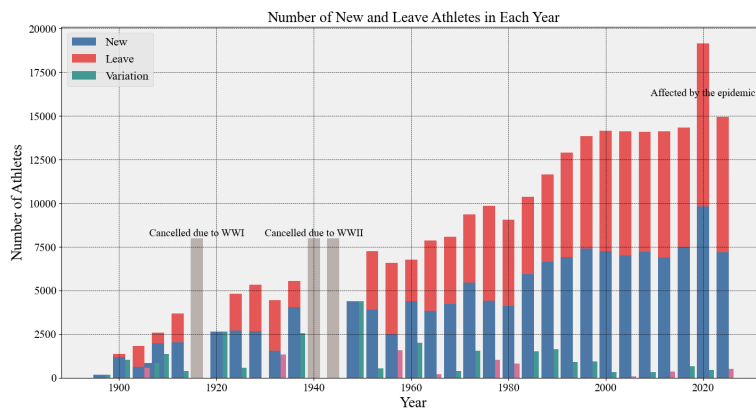


Figure 3: Number of New and Leave Athletes in Each Year
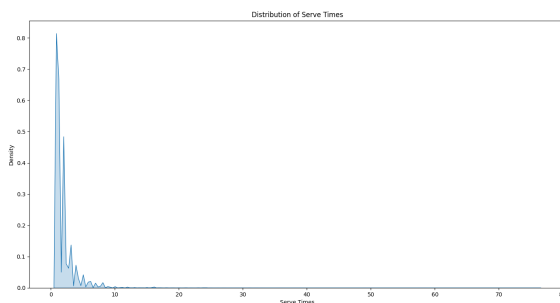


(a) Distribution of Serve Times
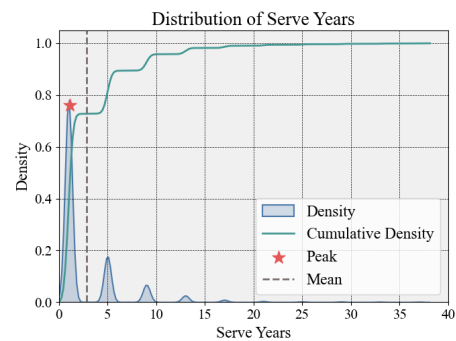
(b) Distribution of Serve Years

Figure 4: Two images
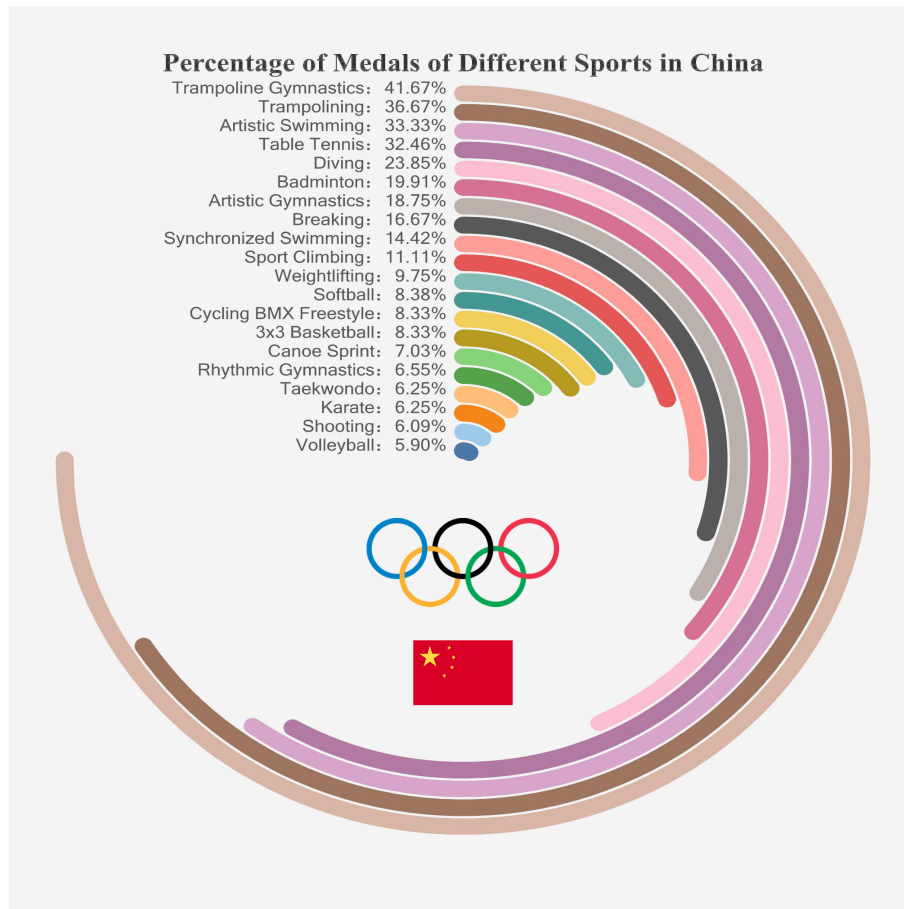
Figure 5: Percentage of Medals of Different Sports in China

## 3.2 Data Mining

### 3.2.1 Athlete Service Status

### 3.2.2 Distribution of Countries' Strength Sports

# 4 Task1:Medal Prediction Model Based on LightGBM

## 4.1 Medal Standings

The detail can be described by equation (**??**):**??**:

$$\gamma = \frac{m_{c_i s_j}}{\sum m_{c_i s_j}} \tag{2}$$

Table 2: Variable Name

| Variable Name | *Code* | Definition |
|---|---|---|

Table 2:  Variable Name (Continued)

| Whether Host Country | *is host* | Whether the country is the host(1 for host,0 for non-host) |
|---|---|---|
| Medal Expectation Increment *Personnel Expectation lncrement | *medal_increment * personnel_increment* | Product of medal expectation increment and personnel expectation increment |
| Sport Advantage Coefficient | *sport_adv* | Advantage coefficient of a specific sport |
| Country Level | *country_lvl* | The level of the country in the competition (ordered by rank) |
| Project Medal Expectation /Project Personnel Expection | *sport_medal _per_ person* | Ratio of sport medals to projected personnel for a specific sport |
| Gold Medal Probability | *gold_prob* | Probability of an athlete winning a gold medal |
| Silver Medal Probability | *silver_prob* | Probability of an athlete  winning a silver medal |
| Bronze Medal Probability | *silver_prob* | Probability of an athletewinning a bronze medal |
| No Medal Probability | *no_medal_probe* | Probability of an athlete winning no medal |

Table 3: Countries' Medal Count Prediction(part)

| Country | G_ pes. | S_ pes. | B_ pes. | G_ opt. | S_ opt. | B_ opt. | Gold | Silver | Bronze | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| United States | 47 | 36 | 23 | 53 | 41 | 25 | 51 | 40 | 25 | 117 |
| China | 35 | 35 | 15 | 46 | 38 | 20 | 40 | 36 | 17 | 95 |
| Australia | 28 | 20 | 22 | 33 | 24 | 24 | 29 | 22 | 23 | 71 |
| France | 23 | 19 | 19 | 27 | 20 | 22 | 24 | 19 | 21 | 64 |
| Germany | 18 | 24 | 14 | 23 | 26 | 16 | 21 | 25 | 15 | 61 |
| United Kingdom | 20 | 19 | 14 | 26 | 24 | 15 | 25 | 21 | 15 | 61 |
| Japan | 16 | 25 | 14 | 19 | 27 | 16 | 17 | 26 | 16 | 58 |
| Italy | 15 | 20 | 15 | 17 | 20 | 22 | 16 | 20 | 16 | 53 |
| Spain | 21 | 10 | 13 | 30 | 12 | 14 | 25 | 12 | 13 | 50 |
| Netherlands | 24 | 6 | 13 | 29 | 9 | 15 | 26 | 8 | 15 | 47 |
| New Zealand | 20 | 13 | 9 | 22 | 15 | 10 | 22 | 14 | 9 | 45 |
| ... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

Figure 6: Medal count prediction

## 4.2 Countries that Win Their First Medal
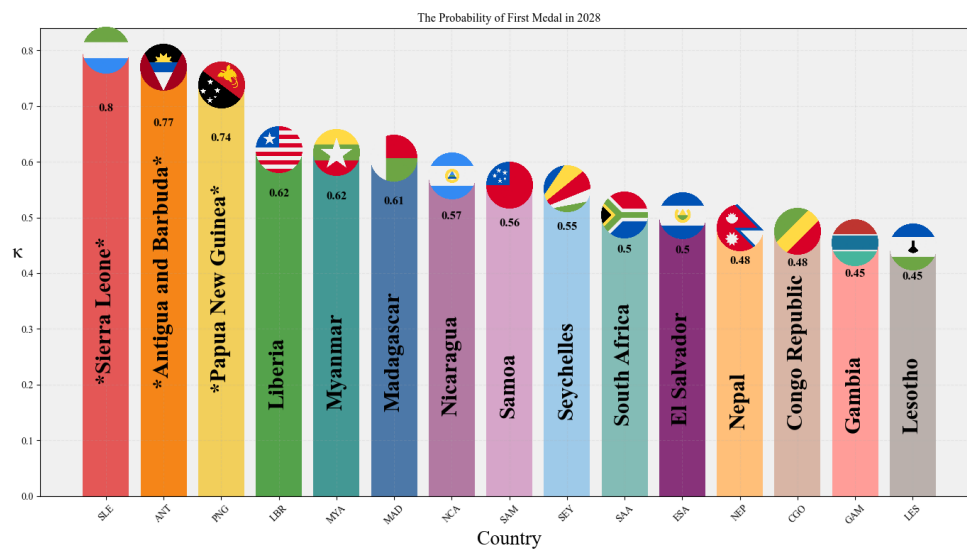


Figure 7: The Probability of First Medal in 2028
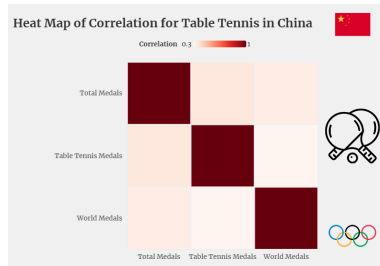
(a) Heatmap of Correlation for Table Tennis in China
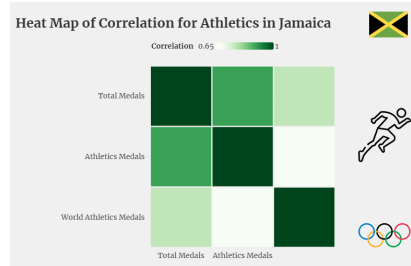
(b) Heatmap of Correlation for Athletics in Jamaica
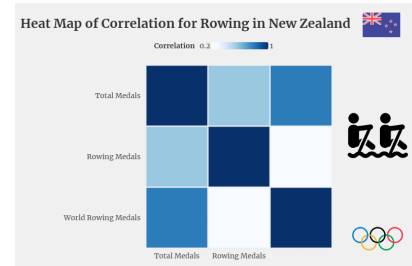
(c) Heatmap of Correlation for Rowing in New Zealand

Figure 8: Three images

## 4.3 Events and Medal Counts by Countries

# 5 Task2:

The results are shown in Figure **??**, where $t$ denotes the time in seconds, and $c$ refers to the concentration of water in the boiler.
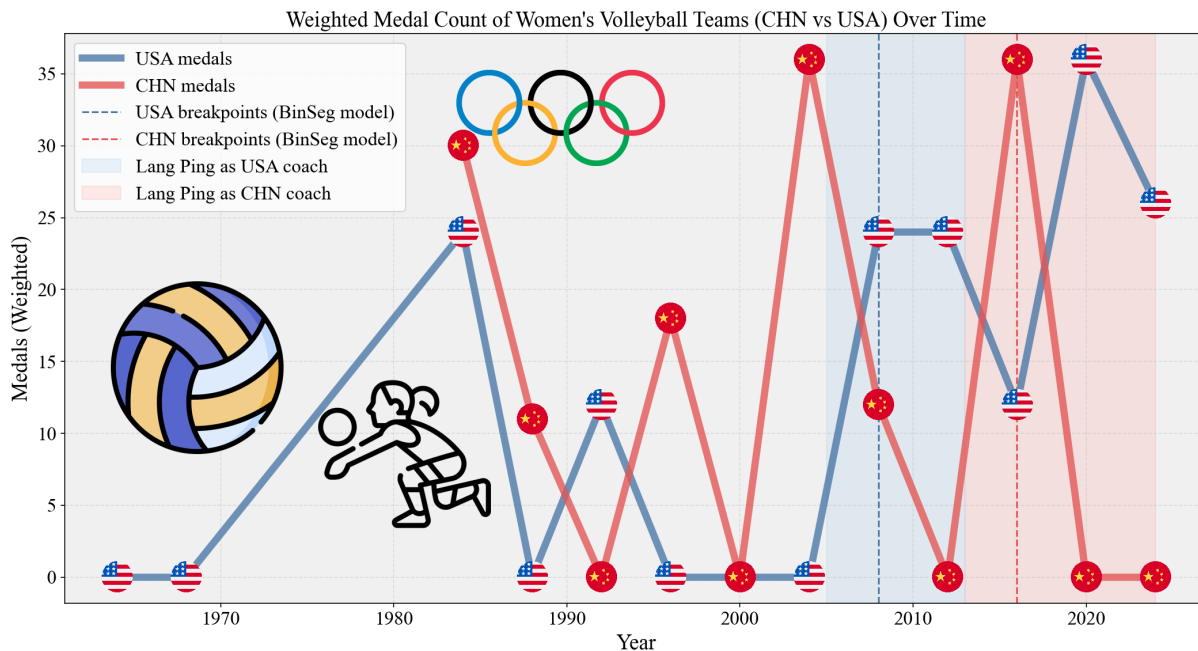


Figure 9: Medal Count of Women's Volleyball Teams(CHN vs USA) Over Time
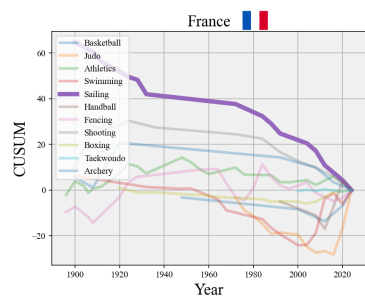
(a) France
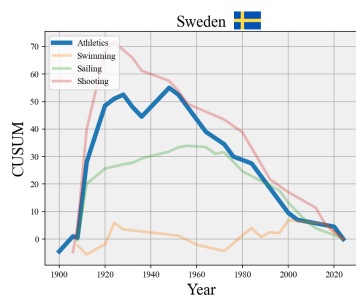
(b) Sweden
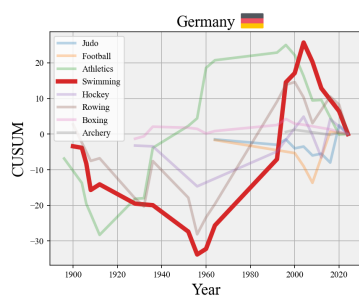
(c) Germany

Figure 10: Three images

Table 4: Model Performances(LightGBM)

| Model | MSE | RMSE | MAE | $R^2$ |
|---|---|---|---|---|
| Gold Prediction | 0.0235 | 0.180 | 0.030 | 0.690 |
| Silver Prediction | 0.0239 | 0.185 | 0.033 | 0.625 |
| Bronze Prediction | 0.0231 | 0.187 | 0.034 | 0.606 |
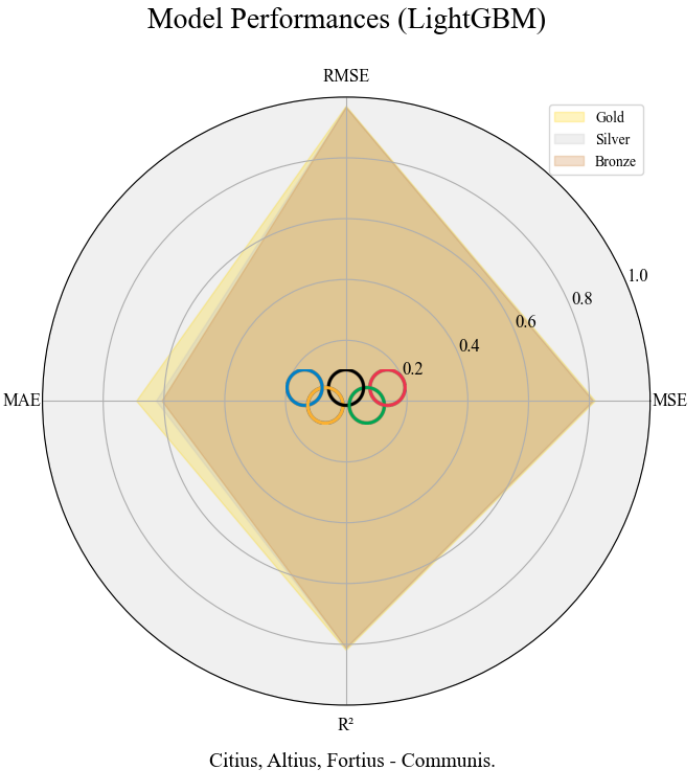


Figure 11: Model Performance Radar Chart

# 6 Task3

$$\mathcal{L} = \sum_{i=1}^{n} L(y_i, \hat{y}_i^{(m-1)} + \eta f_m(x_i)) + \Omega(f_m) \tag{3}$$

$y_i$
$\hat{y}_i^{(m-1)}$
$\eta f_m(x_i)$
$\Omega(f_m)$

$$\kappa = 0.8 \times \frac{\xi - \overline{\xi}}{\sigma} \tag{4}$$

$\overline{\xi}$ $\sigma$

$$d_i = R(X_i) - R(Y_i) \tag{5}$$

$$R_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \tag{6}$$

$d_i$ $R_s$

$$P(c_k \mid X) = \frac{P(X \mid c_k) P(c_k)}{P(X)} \tag{7}$$

$$C_t^+ = \max(0, C_{t-1}^+ + (X_t - \mu - k)) \tag{8}$$

$C_t^+$

$$\phi_i(f) = \sum_{S \subseteq N \setminus \{i\}} \frac{|S|!(|N| - |S| - 1)!}{|N|!} [f(S \cup \{i\}) - f(S)] \tag{9}$$

$\phi_i(f)$

# 7 Sensitivity Analysis

# 8 Model Evaluation

## 8.1 Strengths

1.

2.

3.

4.

## 8.2 Weaknesses

1.

# 9 Conclusion

- Task1

    AA
  bbb

- Task2
  AAA

- Task3
  AAA

- Task4
  AAA

# References

[1] Einstein, A., Podolsky, B., & Rosen, N. (1935). Can quantum-mechanical description of physical reality be considered complete?. *Physical review*, 47(10), 777.

[2] *A simple, easy LaTeX template for MCM/ICM: EasyMCM*. (2018). Retrieved December 1, 2019, from `https://www.cnblogs.com/xjtu-blacksmith/p/easymcm.html`

# Appendix A: Countries' Medal Count Prediction

Table 5: Countries' Medal Count Prediction

| Country | G_ pes. | S_ pes. | B_ pes. | G_ opt. | S_ opt. | B_ opt. | Gold | Silver | Bronze | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| United States | 47 | 36 | 23 | 53 | 41 | 25 | 51 | 40 | 25 | 117 |
| China | 35 | 35 | 15 | 46 | 38 | 20 | 40 | 36 | 17 | 95 |
| Australia | 28 | 20 | 22 | 33 | 24 | 24 | 29 | 22 | 23 | 71 |
| France | 23 | 19 | 19 | 27 | 20 | 22 | 24 | 19 | 21 | 64 |
| Germany | 18 | 24 | 14 | 23 | 26 | 16 | 21 | 25 | 15 | 61 |
| United Kingdom | 20 | 19 | 14 | 26 | 24 | 15 | 25 | 21 | 15 | 61 |
| Japan | 16 | 25 | 14 | 19 | 27 | 16 | 17 | 26 | 16 | 58 |
| Italy | 15 | 20 | 15 | 17 | 20 | 22 | 16 | 20 | 16 | 53 |
| Spain | 21 | 10 | 13 | 30 | 12 | 14 | 25 | 12 | 13 | 50 |
| Netherlands | 24 | 6 | 13 | 29 | 9 | 15 | 26 | 8 | 15 | 47 |
| New Zealand | 20 | 13 | 9 | 22 | 15 | 10 | 22 | 14 | 9 | 45 |
| Canada | 15 | 10 | 16 | 19 | 10 | 18 | 17 | 10 | 16 | 43 |
| Brazil | 8 | 10 | 13 | 8 | 11 | 15 | 8 | 10 | 14 | 32 |
| Belgium | 6 | 8 | 7 | 15 | 10 | 8 | 11 | 8 | 7 | 26 |
| Hungary | 7 | 6 | 8 | 8 | 8 | 9 | 8 | 8 | 9 | 25 |
| Poland | 10 | 7 | 6 | 12 | 10 | 8 | 11 | 9 | 6 | 25 |
| Ireland | 6 | 10 | 6 | 7 | 11 | 6 | 6 | 10 | 6 | 23 |
| Argentina | 4 | 8 | 7 | 5 | 10 | 9 | 4 | 9 | 8 | 22 |
| Denmark | 10 | 7 | 5 | 12 | 8 | 8 | 10 | 8 | 6 | 22 |
| Ukraine | 3 | 7 | 8 | 5 | 8 | 9 | 4 | 8 | 8 | 21 |
| South Korea | 10 | 5 | 4 | 12 | 6 | 4 | 11 | 6 | 4 | 21 |
| Romania | 10 | 7 | 3 | 12 | 8 | 3 | 12 | 7 | 3 | 20 |
| Norway | 11 | 1 | 4 | 11 | 3 | 6 | 11 | 2 | 6 | 19 |
| South Africa | 6 | 4 | 4 | 8 | 8 | 5 | 8 | 7 | 5 | 18 |
| Slovenia | 4 | 3 | 8 | 6 | 3 | 8 | 4 | 3 | 8 | 17 |
| Kenya | 5 | 4 | 4 | 5 | 7 | 5 | 5 | 7 | 4 | 16 |
| Serbia | 4 | 5 | 6 | 5 | 9 | 7 | 4 | 8 | 6 | 16 |
| Mexico | 4 | 4 | 3 | 6 | 4 | 5 | 5 | 4 | 4 | 15 |
| India | 1 | 1 | 4 | 8 | 4 | 5 | 7 | 3 | 4 | 15 |
| Greece | 3 | 4 | 2 | 7 | 4 | 3 | 7 | 4 | 3 | 14 |
| Switzerland | 2 | 4 | 5 | 5 | 4 | 6 | 4 | 4 | 6 | 14 |
| Jamaica | 1 | 7 | 2 | 5 | 12 | 3 | 4 | 8 | 2 | 13 |
| Czech Republic | 5 | 3 | 3 | 6 | 4 | 5 | 6 | 4 | 4 | 13 |
| Uzbekistan | 4 | 2 | 2 | 5 | 3 | 2 | 4 | 2 | 2 | 10 |
| Nigeria | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 2 | 4 | 10 |
| Sweden | 4 | 4 | 2 | 5 | 5 | 5 | 4 | 4 | 2 | 10 |
| Turkey | 3 | 2 | 5 | 3 | 2 | 6 | 3 | 2 | 5 | 10 |
| Finland | 2 | 6 | 2 | 2 | 6 | 2 | 2 | 6 | 2 | 10 |
| Colombia | 5 | 2 | 0 | 5 | 3 | 1 | 5 | 3 | 0 | 9 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Egypt | 0 | 3 | 3 | 1 | 4 | 4 | 0 | 4 | 4 | 8 |
| Kazakhstan | 1 | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 2 | 8 |
| Iran | 2 | 2 | 1 | 5 | 3 | 2 | 4 | 2 | 1 | 8 |
| Dominican Republic | 3 | 3 | 2 | 6 | 4 | 3 | 5 | 3 | 3 | 8 |
| Portugal | 2 | 3 | 3 | 2 | 4 | 3 | 2 | 3 | 3 | 8 |
| Cuba | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 2 | 7 |
| Unknown | 1 | 2 | 2 | 1 | 2 | 4 | 1 | 2 | 2 | 7 |
| Latvia | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 7 |
| Ethiopia | 2 | 1 | 0 | 2 | 6 | 2 | 2 | 2 | 2 | 6 |
| Algeria | 2 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 1 | 6 |
| Morocco | 0 | 2 | 4 | 0 | 2 | 5 | 0 | 2 | 5 | 6 |
| Austria | 3 | 0 | 1 | 3 | 1 | 2 | 3 | 0 | 2 | 6 |
| Puerto Rico | 2 | 3 | 1 | 4 | 3 | 2 | 2 | 3 | 2 | 6 |
| Thailand | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 5 |
| Croatia | 2 | 2 | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 5 |
| Ecuador | 2 | 0 | 2 | 3 | 1 | 3 | 2 | 0 | 3 | 5 |
| Uganda | 0 | 1 | 1 | 1 | 4 | 1 | 1 | 3 | 1 | 5 |
| Angola | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 2 | 0 | 5 |
| Israel | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 5 |
| Mongolia | 1 | 3 | 1 | 1 | 4 | 1 | 1 | 4 | 1 | 5 |
| Fiji | 0 | 1 | 0 | 2 | 5 | 1 | 1 | 4 | 0 | 5 |
| Uruguay | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 2 | 0 | 5 |
| Chile | 0 | 2 | 0 | 1 | 3 | 1 | 0 | 2 | 0 | 5 |
| Unknown | 1 | 1 | 0 | 3 | 1 | 0 | 1 | 1 | 0 | 4 |
| Zambia | 1 | 3 | 0 | 1 | 3 | 0 | 1 | 3 | 0 | 4 |
| Azerbaijan | 1 | 0 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 4 |
| Guinea | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 4 |
| Georgia | 1 | 1 | 0 | 2 | 2 | 0 | 2 | 2 | 0 | 3 |
| Mali | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 3 |
| Chinese Taipei | 2 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 3 |
| Venezuela | 0 | 2 | 1 | 1 | 2 | 2 | 0 | 2 | 2 | 3 |
| Paraguay | 0 | 3 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 3 |
| Indonesia | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 3 |
| Peru | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 2 | 0 | 3 |
| Iraq | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 3 |
| Bulgaria | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 3 |
| Lithuania | 2 | 1 | 0 | 2 | 2 | 1 | 2 | 1 | 1 | 3 |
| Tunisia | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 2 |
| Guatemala | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 2 |
| Bahamas | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 2 | 0 | 2 |
| Trinidad and Tobago | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 2 |

| Montenegro | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 2 |
| Hong Kong | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 2 |
| Moldova | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 1 |
| South Sudan | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 1 |
| Malaysia | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| Philippines | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Bahrain | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 1 |
| Estonia | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| Liberia | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 1 |
| United Arab Emirates | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Jordan | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Eritrea | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 1 |
| Singapore | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| Luxembourg | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Cyprus | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Samoa | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| Qatar | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tanzania | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Djibouti | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ghana | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ivory Coast | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tajikistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kyrgyzstan | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Armenia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Slovakia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Botswana | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Grenada | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zimbabwe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Burundi | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kosovo | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix B: Program Codes

Here are the program codes we used in our research.

**test.py**

```python
# Python code example
for i in range(10):
    print('Hello, world!')
```

**test.m**

```matlab
% MATLAB code example
```

```
for i = 1:10
    disp("hello, world!");
end
```

**test.cpp**

```cpp
// C++ code example
#include <iostream>
using namespace std;

int main() {
    for (int i = 0; i < 10; i++)
        cout << "hello, world" << endl;
    return 0;
}
```