**第二次任务**

时间：1月15日6:00-1月18日22:00，1月19日进行论文总结和汇报PPT制作，1月19日19:30在线汇报、点评。

提交：套用2022年美赛模板制作2023年抬头格式，文件命名规则：“群内队号-成员1-成员2-成员3-论文题目-时间.docx（pdf、rar）”。1月19日中午12：00前将论文发送到caochunzheng@nuist.edu.cn，同时抄送给zhuxiaoxin80@163.com。汇报文件命名规则：“群内队号-成员1-成员2-成员3-第一次汇报.pptx”。以A组为例，提交论文（文件夹）名称：A-桂鹏翔-王佳欣-杨龙-论文题目-时间.docx（pdf、rar），汇报PPT名称：A-桂鹏翔-王佳欣-杨龙-第一次汇报.pptx.

周一然作为总负责的同学，负责整理收集每次组内的论文和汇报PPT。

# 2017 MCM A: Managing The Zambezi River

The Kariba Dam on the Zambezi River is one of the larger dams in Africa. Its construction was controversial, and a 2015 report by the Institute of Risk Management of South Africa included a warning that the dam is in dire need of maintenance. A number of options are available to the Zambezi River Authority (ZRA) that might address the situation. Three options in particular are of interest to ZRA:

(Option 1) Repairing the existing Kariba Dam,

(Option 2) Rebuilding the existing Kariba Dam, or

(Option 3) Removing the Kariba Dam and replacing it with a series of ten to twenty smaller dams along the Zambezi River.

There are two main requirements for this problem:

**Requirement 1** ZRA management requires a brief assessment of the three options listed, with sufficient detail to provide an overview of potential costs and benefits associated with each option. This requirement should not exceed two pages in length, and must be provided in addition to your main report.

**Requirement 2** Provide a detailed analysis of Option (3) - removing the Kariba Dam and replacing it with a series of ten to twenty smaller dams along the Zambezi river. This new system of dams should have the same overall water management capabilities as the existing Kariba Dam while providing the same or greater levels of protection and water management options for Lake Kariba that are in place with the existing dam. Your analysis must support a recommendation as to the number and placement of the new dams along the Zambezi River.

In your report for Requirement 2, you should include a strategy for modulating the water flow through your new multiple dam system that provides a reasonable balance between safety and costs. In addition to addressing known or predicted normal water cycles, your strategy should provide guidance to the ZRA managers that explains and justifies the actions that should be taken to properly handle emergency water flow situations (i.e. flooding and/or prolonged low water conditions). Your strategy should provide specific guidance for extreme water flows ranging from maximum expected discharges to minimum expected discharges. Finally, your recommended strategy should include information addressing any restrictions regarding the locations and lengths of time that different areas of the Zambezi River should be exposed to the most detrimental effects of the extreme conditions.

Your MCM submission should consist of three elements: a standard 1 page MCM Summary Sheet, a 1-2 page brief assessment report (Requirement 1), and your main MCM solution (Requirement 2) not to exceed 20 pages for a maximum submission of 23 pages. Note: Any appendices or reference pages you include will not count towards the 23 page limit.

# MCM B: Roller Coaster

**Background:** A roller coaster is a type of amusement ride that employs a form of elevated railroad track designed with tight turns, steep slopes, and sometimes inversions. People ride along the track in open cars, and the rides are often found in amusement parks and theme parks around the world. LaMarcus Adna Thompson obtained one of the first known patents for a roller coaster design in 1885, related to the Switchback Railway that opened a year earlier at Coney Island. The track in a coaster design does not necessarily have to be a complete circuit, as shuttle roller coasters demonstrate. Most roller coasters have multiple cars in which passengers sit and are restrained. Two or more cars hooked together are called a train. Some roller coasters, notably wild mouse roller coasters, run with single cars.

There are several Roller Coaster rating/ranking sites online that, while taking some objective measures into account, heavily rely on subjective input to determine the rating or ranking of a particular roller coaster (e.g., an "excitement" or "experience" score of an "expert" rider to measure "thrill").

In addressing this MCM problem, consider only roller coasters currently in operation. We have provided data for a subset of operating roller coasters whose height, speed, and/or drop are above the average of worldwide operating coasters. Therefore, we have not included family or kiddie coasters, nor have we included bobsled or mountain type coasters.

**Problem:**

**Part I:** Develop a mathematical model and create an objective quantitative algorithm or set of algorithms to develop a descriptive roller coaster rating/ranking system based only on roller coaster numerical and descriptive specification data (e.g., speed, duration of ride, steel or wood, drop).

**Part II:** Use your algorithm(s) to develop your "Top 10 Roller Coasters in the World" list. Compare and discuss the rating/ranking results and descriptions from your team's algorithm(s) with at least two other rating/ranking systems found online.

**Part III:** Describe the concept and design for a user-friendly app that uses your algorithm(s) to help a potential roller coaster rider find a roller coaster that she or he would want to ride. NOTE: You DO NOT need to program and/or write code for the app. You are developing the concept and design for the app only.

**Part IV:** Write a one-page non-technical News Release describing your new algorithm, results, and app. Prepare a short (1 to 2 pages) synopsis of your results suitable for publication as a short note in IEEE Communications Magazine.

Your submission should consist of:

One-page Summary Sheet,

Two-page synopsis,

Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and synopsis.

Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

**Reference:**

Roller Coaster Database found at: [https://www.rcdb.com](https://www.rcdb.com/)

Roller Coaster and Amusement Park Database found at: <https://www.ultimaterollercoaster.com/>Coasterpedia The Roller Coaster Wiki found at: <https://coasterpedia.net/>

**Attachment:**

ProblemBData： COMAP\_RollerCoasterData\_2019.xlsx

Note: It is not uncommon for real world databases to have some missing, noisy, or inconsistent data.

# 2016 MCM C: The Goodgrant Challenge

The Goodgrant Foundation is a charitable organization that wants to help improve educational performance of undergraduates attending colleges and universities in the United States. To do this, the foundation intends to donate a total of $100,000,000 (US100 million) to an appropriate group of schools per year, for five years, starting July 2016. In doing so, they do not want to duplicate the investments and focus of other large grant organizations such as the Gates Foundation and Lumina Foundation.

Your team has been asked by the Goodgrant Foundation to develop a model to determine an optimal investment strategy that identifies the schools, the investment amount per school, the return on that investment, and the time duration that the organization’s money should be provided to have the highest likelihood of producing a strong positive effect on student performance. This strategy should contain a 1 to N optimized and prioritized candidate list of schools you are recommending for investment based on each candidate school’s demonstrated potential for effective use of private funding, and an estimated return on investment (ROI) defined in a manner appropriate for a charitable organization such as the Goodgrant Foundation.

To assist your effort, the attached data file (ProblemCDATA.zip) contains information extracted from the U.S. National Center on Education Statistics (www.nces.ed.gov/ipeds), which maintains an extensive database of survey information on nearly all post-secondary colleges and universities in the United States, and the College Scorecard data set (https://collegescorecard.ed.gov) which contains various institutional performance data. Your model and subsequent strategy must be based on some meaningful and defendable subset of these two data sets.

In addition to the required one-page summary for your MCM submission, your report must include a letter to the Chief Financial Officer (CFO) of the Goodgrant Foundation, Mr. Alpha Chiang, that describes the optimal investment strategy, your modeling approach and major results, and a brief discussion of your proposed concept of a return-on-investment (ROI) that the Goodgrant Foundation should adopt for assessing the 2016 donation(s) and future philanthropic educational investments within the United States. This letter should be no more than two pages in length.

Note: When submitting your final electronic solution DO NOT include any database files. The only thing that should be submitted is your electronic (Word or PDF) solution.

The ProblemCDATA.zip data file contains:

Problem C - IPEDS UID for Potential Candidate Schools.xlsx

Problem C - Most Recent Cohorts Data (Scorecard Elements).xlsx

Problem C - CollegeScorecardDataDictionary-09-08-2015.xlsx

IPEDS Variables for Data Selection.pdf

You can download the data (ProblemCDATA.zip) on the following websites:

http://www.comap-math.com/mcm/ProblemCDATA.zip http://www.mathismore.net/mcm/ProblemCDATA.zip http://www.mathportals.com/mcm/ProblemCDATA.zip <http://www.immchallenge.org/mcm/ProblemCDATA.zip>

# 2020 ICM D: Teaming Strategies

As societies become more interconnected, the set of challenges they face have become increasingly complex. We rely on interdisciplinary teams of people with diverse expertise and varied perspectives to address many of the most challenging problems. Our conceptual understanding of team success has advanced significantly over the past 50+ years allowing for better scientific, creative, or physical teams to address these complex issues. Researchers have reported on best strategies for assembling teams, optimal interactions among teammates, and ideal leadership styles. Strong teams across all sectors and domains are able to perform complex tasks unattainable through either individual efforts or a sequence of additive contributions of teammates.

One of the most informative settings to explore team processes is in competitive team sports. Team sports must conform to strict rules that may include, but are not limited to, the number of players, their roles, allowable contact between players, their location and movement, points earned, and consequences of violations. Team success is much more than the sum of the abilities of individual players. Rather, it is based on many other factors that involve how well the teammates play together. Such factors may include whether the team has a diversity of skills (one person may be fast, while another is precise), how well the team balances between individual versus collective performance (star players may help leverage the skills of all their teammates), and the team’s ability to effectively coordinate over time (as one player steals the ball from an opponent, another player is poised for offense).

In light of your modeling skills, the coach of the Huskies, your home soccer (known in Europe and other places as football) team, has asked your company, Intrepid Champion Modeling (ICM), to help understand the team’s dynamics. In particular, the coach has asked you to explore how the complex interactions among the players on the field impacts their success. The goal is not only to examine the interactions that lead directly to a score, but to explore team dynamics throughout the game and over the entire season, to help identify specific strategies that can improve teamwork next season. The coach has asked ICM to quantify and formalize the structural and dynamical features that have been successful (and unsuccessful) for the team. The Huskies have provided data (This data set was processed from a much larger dataset covering nearly 2000 matches from five European national soccer competitions, as well as the 2018 World Cup [1]) detailing information from last season, including all 38 games they played against their 19 opponents (they played each opposing team twice). Overall, the data covers 23,429 passes between 366 players (30 Huskies players, and 336 players from opposing teams), and 59,271 game events.

To respond to the Huskie coach’s requests, your team from ICM should use the provided data to address the following:

 Create a network for the ball passing between players, where each player is a node and each pass constitutes a link between players. Use your passing network to identify network patterns, such as dyadic and triadic configurations and team formations. Also consider other structural indicators and network properties across the games. You should explore multiple scales such as, but not limited to, micro (pairwise) to macro (all players) when looking at interactions, and time such as short (minute-to-minute) to long (entire game or entire season).

 Identify performance indicators that reflect successful teamwork (in addition to points or wins) such as diversity in the types of plays, coordination among players or distribution of contributions. You also may consider other team level processes, such as adaptability, flexibility, tempo, or flow. It may be important to clarify whether strategies are universally effective or dependent on opponents’ counter-strategies. Use the performance indicators and team level processes that you have identified to create a model that captures structural, configurational, and dynamical aspects of teamwork.

 Use the insights gained from your teamwork model to inform the coach about what kinds of structural strategies have been effective for the Huskies. Advise the coach on what changes the network analysis indicates that they should make next season to improve team success.

 Your analysis of the Huskies has allowed you to consider group dynamics in a controlled setting of a team sport. Understanding the complex set of factors that make some groups perform better than others is critical for how societies develop and innovate. As our societies increasingly solve problems involving teams, can you generalize your findings to say something about how to design more effective teams? What other aspects of teamwork would need to be captured to develop generalized models of team performance?

Your submission should consist of:

 One-page Summary Sheet

 Table of Contents

 Your solution of no more than 20 pages, for a maximum of 22 pages with your summary and table of contents.

Note: Reference List and any appendices do not count toward the page limit and should appear after your completed solution. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

**Attachment**

2020\_Problem\_D\_DATA.zip

fullevents.csv matches.csv

passingevents.csv

README.txt

**Glossary**

**Dyadic Configurations:** relationships involving pairs of players.

**Triadic Configurations:** relationships involving groups of three players.

**Cited Reference**

[1] Pappalardo, L., Cintia, P., Rossi, A. et al. A public data set of spatio-temporal match events in soccer competitions. Sci Data 6, 236 (2019).

Optional Resources

Research in football (soccer) networks has led to many articles that discuss related topics. A few articles are listed below. You are not required to use any of these sample articles in your solution, nor is it a comprehensive list. We encourage teams to utilize any journal article that supports their approach to the problem.

Buldú, J.M., Busquets, J., Echegoyen, I. et al. (2019). Defining a historic football team: Using Network Science to analyze Guardiola’s F.C. Barcelona. Sci Rep, 9, 13602.

Cintia, P., Giannotti, F., Pappalardo, L., Pedreschi, D., & Malvaldi, M. (2015). The harsh rule of the goals: Data-driven performance indicators for football teams. 2015 IEEE International Conference on Data Science and Advanced Analytics (DSAA), 1-10, 7344823.

Duch J., Waitzman J.S., Amaral L.A.N. (2010). Quantifying the performance of individual players in a team activity. PLoS ONE, 5: e10937.

GÜRSAKAL, N., YILMAZ, F., ÇOBANOĞLU, H., ÇAĞLIYOR, S. (2018). Network Motifs in Football. Turkish Journal of Sport and Exercise, 20 (3), 263-272.

# MCM E: Sustainable Food Prediction

Global food demand is increasing rapidly, as are the environmental impacts of agricultural expansion. Here, we project global demand for crop production in 2050 and evaluate the environmental impacts of alternative ways that this demand might be met. We find that per capita demand for crops, when measured as caloric or protein content of all crops combined, has been a similarly increasing function of per capita real income since 1960. This relationship forecasts a 100-110% increase in global crop demand from 2005 to 2050.

Quantitative assessments show that the environmental impacts of meeting this demand depend on how global agriculture expands. If current trends of greater agricultural intensification in richer nations and greater land clearing (extensification) in poorer nations were to continue, ~1 billion ha of land would be cleared globally by 2050, with CO2-C equivalent greenhouse gas emissions reaching ~3 Gt y-1 and N use ~250 Mt y-1 by then. In contrast, if 2050 crop demand was met by moderate intensification focused on existing croplands of underyielding nations, adaptation and transfer of high-yielding technologies to these croplands, and global technological improvements, our analyses forecast land clearing of only ~0.2 billion ha, greenhouse gas emissions of ~1 Gt y-1, and global N use of ~225 Mt y-1. Efficient management practices could substantially lower nitrogen use. Attainment of high yields on existing croplands of underyielding nations is of great importance if global crop demand is to be met with minimal environmental impacts.

Your tasks are the following:

**Task 1:** Develop a model that determines whether a country is lack of food or not and simultaneously measures the impact of sustainable food and unsustainable food. Your model should identify when a state is sustainable or unsustainable. It should also identify how the quantity of food change increases unsustainability through direct means or indirectly as it influences other factors and indicators.

**Task 2:** Select one of the top 10 countries which have sustainable food as determined by some data on websites and the results according to your model. Then, comparing your results with the rank on some websites. And determine how the quantity of food change may have increased unsustainability of that country. Use your model to show in what way(s) the state may be less sustainable without these effects.

**Task 3:** Use your model on another state not in the top 10 list to measure its unsustainability, and see in what way and when the quantity of food change may push it to become more unsustainable. Identify any definitive indicators. How do you define a tipping point and predict when a country may reach it?

**Task 4:** Use your model to show which state driven interventions could mitigate the risk of the quantity of food change and prevent a country from becoming an unsustainable state. Explain the effect of human intervention and predict the total cost of intervention for this country.

**Task 5:** Will your model work on smaller “states” (such as cities) or larger “states” (such as continents)? If not, how would you modify your model?

**Task 6:** Make a prediction of the quantity of food in 2050 for a country or state you select. Then make a sensitivity analysis of your model.

**Task 7:** Prepare a short (1 to 2 pages) synopsis of your results suitable for sending to the president of the United Nations(UN) for producing a sustainable food.

Your submission should consist of:

 One-page Summary Sheet,

 Two-page synopsis,

 Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and synopsis.

 Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

**References:**

Tilman, D , et al. "Global food demand and the sustainable intensification of agriculture." Proceedings of the National Academy of Sciences of the United States of America 108.50 (2011): 20260-20264.

Godfray, H. Charles J . "The debate over sustainable intensification." Food Security 7.2(2015):1-10.

Mockshell, Jonathan , and J. Kamanda . "Beyond the agroecological and sustainable agricultural intensification debate: Is blended sustainability the way forward?." International Journal of Agricultural Sustainability (2018).

**Helpful Links:**

Food Consumption Database: <https://www.who.int/nutrition/landscape_analysis/nlis_gem_food/en/>

Food Demand in Australia: <http://www.agriculture.gov.au/abares/research-topics/food-demand>