美赛经验分享

张煜坤

北京邮电大学

December 31, 2022

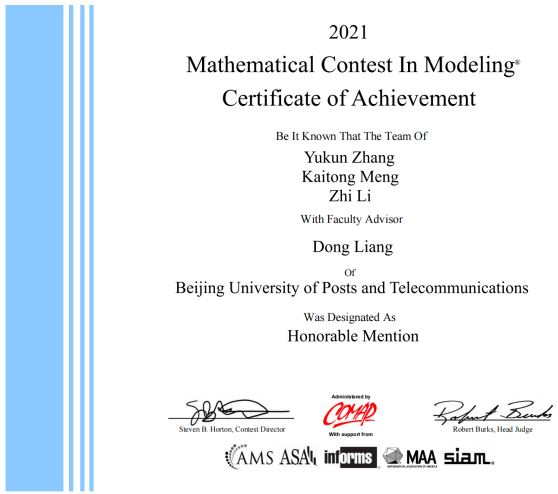
内容

北京郵電大學 Beijing University of Posts and Telecommunications

参赛情况

美国大学生数学建模竞赛（MCM/ICM）

- 题目类型：A：连续型，B：离散型，C，大数据，D：运筹学，E：环境科学，F：政策
- 获奖比例：O：0.14%，F：1%，M：8%，H：30%，S：60%



2021
Mathematical Contest In Modeling®
Certificate of Achievement

Be It Known That The Team Of
Yukun Zhang
Kaitong Meng
Zhi Li
With Faculty Advisor
Dong Liang
Of
Beijing University of Posts and Telecommunications
Was Designated As
Honorable Mention

Steven B. Horton, Contest Director
Robert Burks, Head Judge
AMS ASA informs MAA siam

2022
Mathematical Contest In Modeling®
Certificate of Achievement

Be It Known That The Team Of
Zhi Li
Yukun Zhang
Zhuojia Ma
With Faculty Advisor
Wenbo Zhang
Of
Beijing University of Posts and Telecommunications
Was Designated As
Finalist

Solomon Garfunkel, Executive Director
Steven B. Horton, Contest Director
AMS ASA informs MAA siam

- 参赛情况：参加了 2021 和 2022 年的美赛
- 获奖情况：2021 年得到 H 奖，2022 年得到 F 奖
- 参赛职责：论文书写
- 选择题目：两次均为 B 题

北京郵電大學 Beijing University of Posts and Telecommunications

概念理解

数学建模

- 构建数学模型解决生活实际中的问题
- 分析问题，给出解决方案，小型科研

- 提供应用场景
  课内知识不知道该怎么用，数学建模在实际场景中使用，是数学学习的第二过程
- 区别课内数学
  课内的数学是理想状态下，实际问题是需要估算和简化等操作
- 科学建模流程
  理解问题，拆分问题，解决问题，形成方案
- 实际如何操作
  查找资料，快速学习，迁移应用的能力，它山之石可以攻玉

论文书写

科研论文

- 论文是科研的最终产物，是创新的表现方式
- 格式专业完整，逻辑结构清晰，把问题说清楚三个层次

- 评阅原则
  摘要优先，形式多样化，问题说清楚
- 对应能力
  对于论文格式，论文逻辑关系，图表多样化表达
- 标准格式
  摘要，目录，假设，公式，图像，表格，公式，参考文献，附录
- 如何书写
  问题背景，问题分析，方法理论，建模应用，概括总结，敏感性分析

北京郵電大學 Beijing University of Posts and Telecommunications

摘要示例

Air Support for Fighting Wildfires

Summary

The 2019-2020 bushfire season has seen significant damage in Australia.We helped the National Fire Service design the Integrated Bushfire Response System and calculate the budget accordingly.

To better deploy the UAVs, we developed **the Bushfire Model**.We collected data on the Australian bushfire last year, and we got the area and size of the forest fire in eastern Victoria. Considering that radio communication will be obstructed by the terrain, we developed **the Obstructed Radio Communication Model**. We simplified the calculation of the effect of terrain on radio communication distance based on electromagnetic theory and geospatial information.

We considered SSA UAVs and repeater UAVs separately. To evaluate and analyze the radio transmission capability of frontline forces and repeaters, we developed **the Repeater UAV Network Model**. Based on the method of VORONOI diagram in graph theory with the help of computer simulation, we made the basic planning on the partition of areas or regions. Combining the impact of the actual bushfire region and terrain on radio communication, we designed the optimal number of UAVs and deployment scheme. To evaluate the capability of UAVs to monitor fires, we developed **the SSA UAV Coverage Model**. Based on the characteristics of SSA UAVs, we turned the problem into a multi-UAV cooperative coverage route planning problem. We improved the Ant Colony Algorithm for path optimization and obtained the Rectangular-coverage Centralized Algorithm, which we used to obtain the optimal number of UAVs. Using the Hierarchical Analysis(AHP), we developed **the Integrated Bushfire Response Model**. Based on the Repeater UAV Network Model and the SSA UAV Coverage Model, we assigned appropriate weights to factors such as fire size, terrain, economy, and the capability of damage control to calculate the optimal number and combination of SSA and Repeater UAVs.

To estimate the likelihood of extreme bushfires in the next decade, we developed **the Bushfire Prediction Model**. We calculated the dynamic changes of bushfire regions in the next decade. We calculated the change in the number of UAVs, considering attrition costs. We finally calculated the incremental cost based on future bushfire predictions and attrition probabilities. To explore the impact of different terrain and bushfire sizes on repeater UAVs, we developed **the Repeater Location Model**. Using the Improved VORONOI Graph Algorithm, the distribution of the location of the displayed repeaters was simulated with the help of the computer.

We then performed a sensitivity analysis of the model and provided evidence to demonstrate the stability and reliability of the model. Finally we analyzed the strengths and weaknesses of the model. We also wrote an annotated budget request based on the proposed model to provide to the government for decision making.

Keywords: UAV, Voronoi Diagram, Ant Colony Algorithm, Route Planning, AHP

- 摘要结构：
  问题背景，算法模型，分析评价
- 算法模型：
  针对什么问题，使用什么算法，构建什么模型，得到什么结果
- 分析评价：
  敏感性分析，优缺点，改进方向

北京郵電大學 Beijing University of Posts and Telecommunications

建模算法

通用算法

- 各种问题下均可使用的通用方法
- 熟悉算法的内容

- 学习目标
  能够理解算法的使用场景和如何使用，忽略复杂数学推导
- 方法分类
  优化模型，预测模型，分类模型，评价模型
- 具体介绍
  每个方法的概念理解，使用场景，输入输出，如何使用
- 如何书写
  问题背景，问题分析，方法理论，建模应用，概括总结，敏感性分析

北京郵電大學 Beijing University of Posts and Telecommunications

建模算法

特殊算法

- 仅解决特定问题所使用的算法
- 练习学习算法的过程

- 查找算法
  按照问题查找，按照方法名称查找，论文网站查找，小技巧
- 算法学习理解
  快速理解问题的输入输出，方法的主要思想，不要纠结于细节
- 算法筛选迁移
  选择成熟的有把握的算法，根据已有的算法进行迁移
- 算法的表示
  变量设定和问题假设，公式表示，算法步骤流程图，结果的合理简化

工具使用

核心思想

- 让每个模型的每个部分的结论都能够以直观多样的方式展示出来

- 论文排版
  LaTex——熟练掌握各种格式的语法

- 算法计算
  MATLAB——实际计算，矩阵的计算，复杂公式的计算，自动机，聚类等算法

- 数据处理
  Python——数据的可视化，包括简单二三维数据，大型统计数据

- 图像绘制
  亿图图示——流程图，示意图的画法

- 特定图像
  特定地区地图绘制，图像示意图画法

北京郵電大學 Beijing University of Posts and Telecommunications

图像示例

图像绘制示例

Figure 7: Electricity and water distribution of states

As stated in the supply and demand analysis, once the water needs of the states are met, we maximize the amount of hydroelectric power.

Specifically reflected in the data, maximize the sum of the water released by the Glen Canyon Dam and the Hoover Dam. This part has been calculated in the water transfer model, which are $1 \times 10^9 m^3$ and $1.8 \times 10^9 m^3$ respectively. Adding them together gives a maximum value of $2.8 \times 10^9 m^3$.

Finally, it can be allocated proportionally according to the electricity demand of each state.

Figure 8: Water distribution of Hoover

Figure 9: Water distribution of Glen Canyon

Figure 1: 结果示意图

4.1.1 Background Analysis

In order to understand the extent and severity of fire distribution for the deployment of UAVs and search and rescue operations, we built a fire distribution model. We collected data [9] from this Australian forest fire to obtain the fire distribution and severity of the fires occurring in eastern Victoria. With the help of geographic analysis software, we estimated the major area of the fires. Using the model, we were able to determine the size of the area in which the UAV would work.

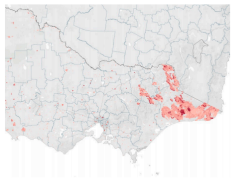


Figure 1: Fire Distribution Map

4.1.2 Model Construction

By retrieving information through the Internet, we succeeded in obtaining statistical data [8] on the occurrence of fires in Australia. Then, we used computer simulation and measurement to estimate the fire distribution map as shown in Figure 1. This map is mainly for the distribution of fires in Victoria, Australia. The map shows that fires in Australia are concentrated in the eastern part of Victoria and the southern border of New South Wales, with sporadic distribution in the southwest. The red areas marked on the map are fire areas. The shades of color indicate the extent of the fires that have occurred.

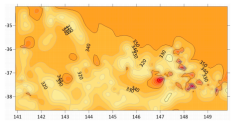
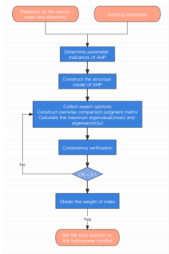


Figure 2: Fire Distribution Analysis Map

Figure 2: 特殊示意图

5.3.2 Algorithm process

- **Step1** For the overall goal of solving conflict between water and electricity, divide the target into multiple single objectives.
- **Step2** Determine the elements and indicators level of different objectives in the specific division. Invite the committee to give corresponding scores to build a judgment matrix.
- **Step3** Extract the effective information from the judgment matrix and use the effective information to calculate the weight vector.
- **Step4** Based on the weight vector, check the consistency of the matrix to judge whether it is consistent.



The specific algorithm process is as follows:

Through the data collecte from the investigation, clarify the specific objectives of solving water and hydropower conflicts and determine the indicators parameters.

- **Objective:** Reasonably solve conflicts between water and electricity.
- **Criteria:** Comprehensively consider the impact of water and electricity on economy, society and environment. Then select the following five criteria indicators as follows. A1 Resource Scarcity, A2 Ecological Environment, A3 Utilization Efficiency, A4 Economic Benefits, A5 Social Impact.
- **Scheme** B1: Water supply priority, B2: Power supply priority, B3: Simultaneous water and electricity supply.

Figure 3: 算法流程图

- 将结果用可视化的形式进行展示
- 对于地理信息等数据进行可视化
- 为每个算法配上步骤流程

协作模式

多种模式，灵活协作

- 形式分为集合讨论和独立分工
- 谨记任务分工原则，按照比赛流程推进

- 集合讨论模式
  成员完成同一项任务，在选题的头脑风暴期间，问题方法的筛选期间，互相讨论提出问题
- 独立分工模式
  成员完成不同的任务，在实际的操作中，按照小任务，快迭代的方式，完成各自的任务
- 任务分工原则
  要明确分任务的输入输出，设定时间，方便交接，尽量任务不要有交叉
- 比赛流程事项
  分析题目，查找资料，选择题目，拆分题目，选择算法，完成结论，叙述算法，优化论文

分工侧重

各取所长，清晰分工

- 分成三个职责，论文写作，数学建模，图像表示
- 组长负责任务分配和论文写作

- 论文写作
  通常作为团队的组长和任务分配者，按照整体的进度，组织讨论，划分任务，负责论文书写
- 数学建模
  负责具体的数学公式部分的理解和迁移，给出具体的公式和结果，确保模型的准确性
- 图像表示
  根据模型和论文提供算法代码的输出，绘制相应的示意图和图示结果

致谢

祝大家都能取得理想成绩！

感谢同学们的倾听，鉴于个人水平有限，还请同学们批评指正！

邮箱：zhangyukun@bupt.edu.cn　　电话：15936291829

北京郵電大學
Beijing University of Posts and Telecommunications