

1985-2020 历年美赛赛题

中文翻译版

美赛参赛必备
小米辣数学建模工作室整理

目录

MCM1985 问题-A 动物群体的管理.....	1
MCM1985 问题-B 战购物资储备的管理.....	1
MCM1986 问题-A 水道测量数据.....	2
MCM1986 问题-B 应急设施的位置.....	2
MCM1987 问题-A 盐的存贮.....	3
MCM1987 问题-B 停车场.....	3
MCM1988 问题-A 确定毒品走私船的位置.....	4
MCM1988 问题-B 两辆铁路平板车的装货问题.....	4
MCM1989 问题-A 蠼的分类.....	4
MCM1989 问题-B 飞机排队.....	5
MCM1990 问题-A 药物在脑内的分布.....	5
MCM1990 问题-B 扫雪问题.....	5
MCM1991 问题-A 估计水塔的水流量.....	5
MCM1991 问题-B 通讯网络的极小生成树.....	6
MCM1992 问题-A 空中交通控制雷达的功率问题.....	6
MCM 1992 问题-B 应急电力修复系统的修复计划.....	6
MCM1993 问题-A 加速餐厅剩菜堆肥的生成.....	7
MCM1993 问题-B 倒煤台的操作方案.....	7
MCM1994 问题-A 住宅的保温.....	8
MCM 1994 问题-B 计算机网络的最短传输时间.....	8
MCM-1995 问题-A 单一螺旋线.....	9
MCM1995 问题-B Aluacha Balaclava 学院.....	10
MCM1996 问题-A 噪音场中潜艇的探测.....	10
MCM1996 问题-B 竞赛评判问题.....	10
MCM1997 问题-A Velociraptor(疾走龙属)问题.....	11
MCM1997 问题-B 为取得富有成果的讨论怎样搭配与会成员.....	12
MCM1998 问题-A 磁共振成像扫描仪.....	12
MCM1998 问题-B 成绩给分的通胀.....	13
MCM1999 问题-A 大碰撞.....	13
MCM1999 问题-B “非法”聚会.....	14
ICM1999 问题-C Ground Pollution.....	14
MCM2000 问题-A 空间交通管制.....	15
MCM2000 问题-B: 无线电信道分配.....	16
ICM 2000 问题-C: Elephants: When is Enough, Enough?.....	16
MCM2001 问题-A: 选择自行车车轮.....	18
MCM2001 问题-B 逃避飓风怒吼（一场恶风...）.....	19

ICM2001 问题-C 我们的水系-不确定的前景.....	20
MCM2002 问题-A 风和喷水池	23
MCM2002 问题-B 航空公司超员订票.....	23
MCM2002 问题-C: 灌木蜥蜴.....	24
MCM2003 问题-A: 特技演员	27
MCM2003 问题-B: Gamma 刀治疗方案.....	27
MCM2003 问题-C 航空行李的扫描对策.....	28
MCM2004 问题-A: 指纹是独一无二的吗?	31
MCM2004 问题-B: 更快的快通系统.....	31
MCM2004 问题-C 安全与否?	31
MCM2005 问题 A.水灾计划.....	36
MCM2005 问题 B 收费亭	36
MCM2005 问题 C: 不可再生的资源.....	36
MCM2006 问题 A: 用于灌溉的自动洒水器的安置和移动调度.....	37
MCM2006 问题 B: 通过机场的轮椅.....	37
MCM2006 问题 C: 抗击艾滋病的协调.....	38
MCM2007 问题-A:不公正划分选区	40
MCM2007 问题-B 飞机座位的问题.....	41
ICM2007 问题-C 器官移植:肾交换问题.....	41
MCM2008 问题 A:给大陆洗个澡.....	43
MCM2008 问题 B: 建立数独拼图游戏.....	43
ICM2008 问题 C: 寻找好的卫生保健系统.....	44
MCM2009 问题 A: 设计一个交通环岛.....	45
MCM2009 问题 B: 能源和手机.....	45
ICM2009 问题 C: 构建食物系统: 重新平衡被人类影响的生态系统	46
MCM2010 Problem A: The Sweet Spot.....	50
MCM2010 问题-A: 最佳击球点	51
MCM2010 Problem B: Criminology.....	51
MCM2010 问题-B: 犯罪学	52
ICM2010 问题-C: 海洋垃圾积累所带来的复杂的问题.....	52
MCM2011 Problem A: Snowboard Course.....	53
MCM2011 问题-A: 滑雪场问题.....	53
MCM2011 Problem B: Repeater Coordination	53
MCM2011 问题-B: 中继站的协调.....	54
ICM2011 问题-C: 电动汽车.....	55
MCM2012 Problem A: The Leaves of a Tree.....	56
MCM 2012 A-题: 树的叶子.....	56
MCM 2012 Problem B: Camping along the Big Long River	56
MCM 2012 问题-B: 大长河沿岸露营.....	57
ICM 2012 问题-C 题: 犯罪克星.....	57
MCM2013 Problem A The Ultimate Brownie Pan.....	61
MCM 2013 问题-A: 最佳巧克力蛋糕烤盘	62

MCM 2013 Problem B: Water, Water, Everywhere.....	63
MCM 2013 问题-B: 水, 水, 无处不在.....	63
ICM2013 问题-C: 地球健康的网络模型.....	63
MCM2014 Problem A: The Keep-Right-Except-To-Pass Rule.....	65
MCM 2014 问题-A: 除非超车否则靠右行驶的交通规则.....	65
MCM 2014 Problem B: College Coaching Legends.....	66
MCM 2014 问题-B: 大学教练传奇.....	66
ICM 2014 问题-C: 网络科学出版物的清单.....	67
MCM2015 Problem A: Eradicating Ebola.....	68
MCM2015 问题-A: 根除埃博拉病毒.....	68
MCM2015 Problem B: Searching for a lost plane.....	68
MCM2015 问题-B: 寻找失踪的飞机.....	69
ICM2015 问题-C: 组织机构下的人力资本管理.....	69
ICM2015 问题-D: 这是可持续的吗?.....	71
MCM2016 Problem A A Hot Bath.....	73
MCM2016 问题- A 热水澡.....	73
MCM2016 Problem B Space Junk.....	74
MCM2016 问题-B 太空垃圾.....	74
MCM2016 Problem C The Goodgrant Challenge.....	75
MCM2016 问题-C goodgrant 的挑战.....	76
ICM 2016 Problem D Measuring the Evolution and Influence in Society's Information Networks.....	77
ICM2016 问题-D 社会信息网络的演变和影响评估.....	79
ICM 2016 Problem E Are we heading towards a thirsty planet?.....	80
ICM2016 问题-E 我们朝着干渴的星球迈进吗?.....	82
ICM 2016 Problem F Modeling Refugee Immigration Policies.....	84
ICM2016 问题-F 难民移民政策模型.....	86
MCM 2017 Problem A: Managing The Zambezi River.....	88
MCM2017 问题- A 管理赞比西河.....	88
MCM 2017 Problem B: Merge After Toll.....	89
MCM2017 问题- B 高速路的收费站.....	90
MCM 2017 Problem C: "Cooperate and navigate".....	90
MCM2017 问题- C "合作和导航".....	91
ICM 2017 Problem D: Optimizing the Passenger Throughput at an Airport Security Checkpoint.....	92
ICM2017 问题- D: 在机场安全检查站优化乘客吞吐量.....	94
ICM 2017 Problem E: Sustainable Cities Needed!.....	96
ICM2017 问题- E: 需要可持续城市!.....	98
ICM 2017 PROBLEM F: Migration to Mars: Utopian Workforce of the 2100 Urban Society.....	99
ICM2017 问题- F: 迁移到火星: 2100 城市社会的乌托邦劳动力.....	102
MCM 2018 Problem A: Multi-hop HF Radio Propagation.....	104
MCM 2018 问题-A: 多跳 HF 无线电传播.....	105
MCM 2018 Problem B: How Many Languages?.....	106
MCM 2018 问题-B: 多少种语言?.....	110
MCM 2018 Problem C: Energy Production.....	114

MCM 2018 问题-C: 能源生产.....	115
ICM 2018 Problem D: Out of Gas and Driving on E (for electric, not empty).....	116
ICM 2018 问题-D: 停止使用燃气和用电驾驶(电, 不是空的)	118
ICM 2018 Problem E: How does climate change influence regional instability?.....	120
ICM 2018 问题-E: 气候变化如何影响地区不稳定?	121
ICM 2018 Problem F: Cost of Privacy.....	122
ICM 2018 问题 F: 隐私成本.....	124
MCM 2019 Problem A: Game of Ecology.....	126
MCM 2019 问题-A: 生态游戏	127
MCM 2019 Problem B: Send in the Drones: Developing an Aerial Disaster Relief.....	128
MCM 2019 问题-B: 发送无人机: 开发空中灾难救援响应系统.....	132
MCM 2019 Problem C: The Opioid Crisis.....	136
MCM 2019 问题-C: 阿片类药物危机.....	138
ICM 2019 Problem D: Time to leave the Louvre	140
ICM 2019 问题-D: 离开卢浮宫的时间	141
ICM 2019 Problem E: What is the Cost of Environmental Degradation?.....	143
ICM 2019 问题-E: 环境退化的代价是什么?	145
ICM 2019 Problem F: Universal, Decentralized, Digital Currency: Is it possible?	146
ICM 2019 问题-F: 通用, 分散, 数字货币:有可能吗?.....	148
MCM 2020 Problem A: Moving North.....	150
MCM 2020 问题-A: 向北迁徙	151
MCM 2020 Problem B: The Longest Lasting Sandcastle(s)	153
MCM 2020 问题-B: 最持久的沙堡.....	153
MCM 2020 Problem C: A Wealth of Data.....	154
MCM 2020 问题-C: 数据的财富.....	156
ICM 2020 Problem D: Teaming Strategies.....	158
ICM 2020 问题-D: 合作策略	159
ICM 2020 Problem E: Drowning in Plastic.....	161
ICM 2020 问题-E:淹没在塑料中	162
ICM 2020 Problem F: The Place I Called Home... ..	163
ICM 2020 问题-F: 那个我称之为家的地方... ..	166

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MCM1985 问题-A 动物群体的管理

在一个资源有限，即有限的食物、空间、水等等的环境里发现天然存在的动物群体。试选择一种鱼类或哺乳动物(例如北美矮种马、鹿、兔、鲑鱼、带条纹的欧洲鲈鱼)以及一个你能获得适当数据的环境，并形成对该动物群体的捕获量的最佳方针。

MCM1985 问题-B 战购物资储备的管理

钴对许多工业是必不可少的(1979 年仅国防需要就占了全世界钴生产量的 17%)，但是钴不产生在美国。大部分钴来自政治上不稳定的构 F 地区。见图 85B-1，85B-2，85B-3。

1946 年制订的战略和稀有作战物资存贮法令要求钴的储存量应保证美国能渡过三年战争时期。50 年代政府按要求存贮了，并在 70 年代卖掉了大部分贮量，而在 70 年代后期决定重新贮存，贮存的指标是 8540 万磅，到 1982 年获得了贮量的一半。

试建立一个战略金属钴的储存管理数学模型。你需要考虑诸如以下的问题：贮量应多大？应以多大的比率来获得贮量？买这些金属的合理价格应该是多少？还要求你考虑诸如以下的问题，贮量达到多大时应开始减少贮存量？应以多大的比率来减少？卖出这些金属的合理价格应该是多少？应该怎样分配(附页中有关于钴的资源、价格、需求及再循环等方面的信息)

关于钴有用信息：

1985 年政府计划需要 2500 万磅钴。进行周而复始的生产经营，从而每年可生产 600 万磅钴。1980 年占总消耗量 70 银的 120 万磅钴再循环了，得到了重新处理。

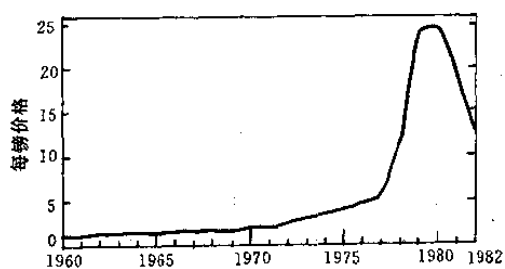


图 85B-2 1960~1980 年美国市场上钴的价格

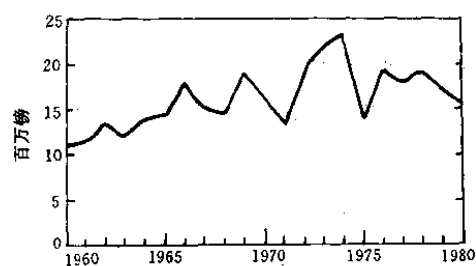


图 85B-1 1960~1980 年美国钴的毛需求

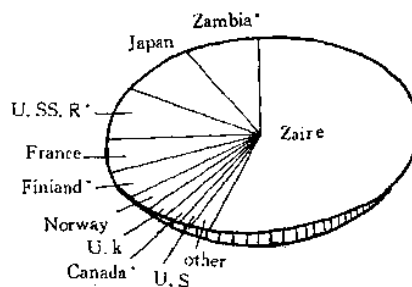


图 85B-3 1979 年精炼的金属以及(或者)氧化物的生产国
(及其所占的比例)

MCM1986 问题-A 水道测量数据

表 86A-1 给出了在以码为单位的直角坐标为 X, Y 的水面一点处以英尺计的水深 Z 。水深数据是在低潮时测得的。船的吃水深度为 5 英尺。在矩形区域 $(75, 200) \times (-50, 150)$ 里的哪些地方船要避免进入。

表 86A-1 水道测量数据, 在低潮时测得的水深

X	129.0	140.0	103.5	88.0	185.5	195.0	105.5
	157.5	107.5	77.0	81.0	162.0	162.0	117.5
Y	7.5	141.5	23.0	147.0	22.5	137.5	85.5
	-6.5	-81.0	3.0	56.5	-66.5	84.0	-33.5
Z	4	8	6	8	6	8	8
	9	9	8	8	9	4	9

本题是由加州海军研究生院数学系的 Richard Franke 提供的, 可阅他的论文 Scattered Data Interpolation, Math, Comput., 38(1982), 181-200。

MCM1986 问题-B 应急设施的位置

“里奥兰翘镇”迄今还没有自己的应急设施。1986 年该镇得到了建立两个应急设施的安全拨款。每个设施都把救护站、消防队和警察所合在一起。图 86B-1 指出了 1985 年每个长方街区应急事件的次数。在北边的上形状的区域是一个障碍, 而在南边的长方形区域是一个有浅水池塘的公园。应急车辆驶过一条南北向的街道平均要花 15 秒, 而通过一条东西向的街道平均要花 20 秒。你的任务就是确定这两个应急设施的位置, 使得总的响应时间最少。

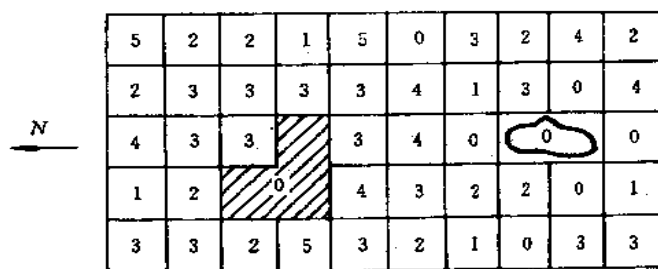


图 86B-1 1985 年里奥兰遍每个长方街区应急事件的数目

- ① 假定需求集中在每个街道的中心而应急设施位于街角处;
 ② 假定需求是沿包围每个街区的街道上平均分布的, 而应急设施可位于街道任何地方。
 本题是由马里兰州沙里斯勃莱州立学院地理学与地区规划系的 J.C. McGrew 提供的。

MCM1987 问题-A 盐的存贮

美国中西部一个州把冬天用来洒在马路上的盐存贮在一个球顶仓库里大约有 15 年了。图 87A-1 表示在过去 15 年中盐是怎么存贮的*通过驾驶铲斗车在由盐铺成的坡道上进出仓里并利用铲斗车上的铲子把盐装进仓里或从仓里取出来。

最近, 一个小组确定这种做法是不安全的。如果铲斗车太靠近盐堆的顶端, 盐就要滑动, 而铲斗车就要翻到为加固仓库而筑的拥壁上去。小组建议, 如果盐堆是用铲斗车堆起来的, 那么盐堆的最高高度不要超过 15 英尺。对这种情况建立一个数学模型并求得在仓库中的盐堆的最大高度。图中仓高 50 英尺, 拥壁高 4 英尺, 仓的外直径 103 英尺, 门的净空高 19 英尺 9 英寸, 铲斗车高 10 英尺 9 英寸。

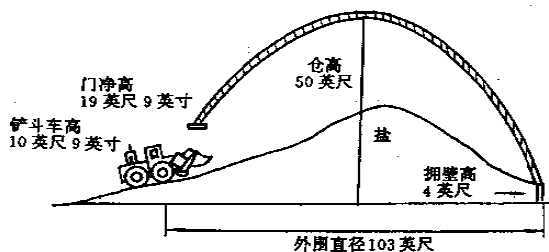


图 87A-1

本题是由印第安纳大学的 M.Thompon 提供的, 是从出现在 1986 年 11 月的 Indianapolis Star 的一个实际问题改造而成的。

MCM1987 问题-B 停车场

在新英格兰地区一个镇上位于街角处的一个停车场的场主雇你来设计该停车场的安排, 即设计“在地上的线应怎样划法”。

你一定认识到要把尽可能多的车塞进停车场会导致以直角停靠的方式一辆挨一辆地排成行。但是缺乏经验的司机对于这种停靠方式是有困难的, 这可能引起昂贵的保险费要求。为了减少停靠车辆时可能造成的损坏, 场主就要启用一些熟练的汽车司机作为

“专职停靠司机”。另一方面, 如果汽车从通道进来有一个足够大的“转弯半径”的话, 那么大多数司机看来都不会有很大的困难一次就停靠到该停靠的位置上去。当然通道愈宽能容

纳的车辆就愈少，这就会导致停车场场主收入的减少。
本题是由加州海军研究生院的 M. D.Weir 提供的。

MCM1988 问题-A 确定毒品走私船的位置

相距 5.43 哩的监听站收听到一个短暂的无线电信号。收听到讯早的时候测向仪分别定位在 111° 和 119° 处（见图 88A-1），测向仪的精度为 $\pm 2^\circ$ ，该讯号来自一个毒品交换活跃的地方，据推测该处有一只机动船正等着有人来取毒品。当时正值黄昏、无风、无潮流。一架小型直升飞机离开监听站①的简易机场并能精确地沿 111° 角方向飞行。直升飞机的飞行速度是走私船的三倍。在离船 500 英尺时船上能听到直升飞机的声音。直升飞机只有一种侦察仪器--探照灯。在 200 英尺远的地方探照灯只能照明半径为 25 英尺的圆域。

①说明飞行员能找到正等着的毒品船的(最小)区域。

②研究一种直升飞机的最佳搜索方法。

在你的计算中要有 95% 的精度。

本题是由加州 Claremont McKenna 学院的 J.A.Ferling 提供的。这是一个分类(分组问题)的修正简化形式。原问题和现在简化的问题都还没有一种已知的最化解法。

MCM1988 问题-B 两辆铁路平板车的装货问题

有七种规格的仪装箱要装到两辆铁路平板车上去。包装箱的宽利高是一样的，但厚度(t ，以厘米计)及重量(w ，以公斤计)是不同的。表 88B-1 给出了每种包装箱的厚度、重量以及数量。图 88B-1 中每辆平板车有 10.2 米长的地方可用来装包装箱（象面包片那样），载重为 40 吨。由于当地货运的限制，对 C5, C6, C7 类的包装箱的总数有一个特别的限制；这类箱子所占的空间(厚度)不能超过

302.7 厘米。试把包装箱装到干板车上去使得浪费的空间最小。

本题是由佐治亚理工学院的 J. Bartholdi 提供的。这是出现在福特汽车公司的一个尚未解决的问题的修正与简化。J. Bartholdi 还写了一篇评论性文章 The Outstanding Railroad Flatcar Papers, The UMAP Journal, v.9(1988), no.4, 399-103.

MCM1989 问题-A 蝶的分类

两种蝶 Af 和 Apf 已由生物学家 W.L.Grongan 和 W.W.Wirth(1981 年)根据它们的触角长度和翼长加以区分(见图 89A-1)，9 只 Af 蝶用标记，6 只 Apf 蝶用“.”标记。根据给出的触角长度和翼长识别出一只标本是 Af 还是 Apf 是重要的。

①给定一只 Af 或者 Apf 族的蝶，你如何正确地区分它属于哪一族？

②将你的方法用于触角长和翼长分别为(1.24, 1.80)、(1.28, 1.84)、(1.40, 2.04)的三个标本。

③设 Af 是宝贵的传粉益虫，Apf 是某种疾病的载体，是否应该修改你的分类方法，若需修改，怎么改？

MCM1989 问题-B 飞机排队

机场通常都是用“先来后到”的原则来分配飞机跑道，即当飞机准备好离开登机口时，驾驶员电告地面控制中心，加入等候跑道的队伍。

假设控制塔可以从快速联机数据库中得到每架飞机的如下信息：

- ①预定离开登机口的时间；
- ②实际离开登机口的时间；
- ③机上乘客人数；
- ④预定在下一站转机的人数和转机的时间；
- ⑤到达下一站的预定时间。

又设共有七种飞机，载客量从 100 人起以 50 人递增，载客最多的一种是 400 人。

试开发和分析一种能使乘客和航空公司双方满意的数学模型。

本题是由纽约市立大学约克学院的 Joseph Malkevitch 提供的。

MCM1990 问题-A 药物在脑内的分布

研究脑功能失调的人员欲测试新的药物的效果，例如治疗帕金森症往脑部注射多巴胺(Dopamine)的效果，为了精确估计药物影响到的脑部区域，他们必须估计注射后药物在脑内空间分布区域的大小和形状。

研究数据包括 50 个圆柱体组织样本的每个样本药物含量的测定值(如图 90A-1)，每个圆柱体长 0.76mm，直径 0.66mm，这些互相平行的圆柱体样本的中心位于网络距为 $1\text{mm} \times 0.76\text{mm} \times 1\text{mm}$ 的格点上，所以圆柱体互相向在底面上接触，侧面互不接触。注射是在最高计数的那个圆柱体的中心附近进行的。自然在圆柱体之间以及由圆柱体样本覆盖的区域外也有药物。

试估计受到药物影响的区域个药物的分布。

MCM1990 问题-B 扫雪问题

地图如图 90B-1 中的实线表示马里兰州威考密科县中扫雪区域中的二车道马路，虚线表示州属高速公路。一场雪后，从位于地图 b 标记地点以西 4 英里的二处车库派出两辆扫雪车。求用两辆扫雪车扫清马路上的雪的有效的方法，扫雪车可以利用高速公路进出扫雪区。假设扫雪车既不会发生故障也不停顿，在交叉路口不得特别的扫雪方法。

MCM1991 问题-A 估计水塔的水流量

美国某州的各用水管理机构要求各社区提供以每小时多少加仑计的用水率以及每天所用的总水量，但许多社区并没有测量流入或流出当地水塔的水量的设备，他们只能代之以每小时测量水塔中的水位，其精度在 0.5% 以内。更为重要的是，无论什么时候，只要水塔中的水位下降到某一最低水位 L 时，水泵就启动向水塔重新充水直至某一最高水位只，但也无法得到水泵的供水量的测量数据。因此，在水泵正在工作时，人们不容易建立水塔中的水位与水泵工作时的用水量之间的关系。水泵每天向水塔充水一次或两次，每次约二小时。

试估计在任何时刻，甚至包括水泵正在工作的时间内，水从水塔流出的流量 $f(t)$ ，并估计一

天的总用水量。

MCM1991 问题-B 通讯网络的极小生成树

两个通讯站间通讯线路的费用与线路的长度成正比。通过引入若干个“虚设站”并构造一个新的 Steiner 树就可以降低由一组站生成 N 个站的极小生成树所需的费用。用这种方法可降低费用多达 $\frac{1}{2}$ 。而且为构造一个有 n 个站的网络的费用最低的 Steiner 树绝不需要多于 $(n-2)$ 个虚设站。下面是两个简单的例子。

对于局部网络而言，有必要用折线距离或“棋盘”距离来代替欧氏直线距离。假定你希望设计一个有 9 个站的局部网络的最低造价生成树。这 9 个站的直角坐标是：限定你只能用直线，而且所有的虚设站必须位于格点上(即其坐标是整数)。每条直线段的造价是其长度值。

- ① 求该网络的一个极小费用树。
- ② 假定每个站的费用为 w ，其中 d =通讯站间距，若 $w=1.2$ ，求极小费用树。
- ③ 试推广本问题。

本题是由马里兰州沙里斯勃莱州立大学数学科学系 B.A.Fusaro(他也是 MCM 的 Director)提供的，他是受启发于 Cipra.Barry A. . Euclidean geometry alive and well in the computerage. SIAM New5, v.24(1991), no.1, 16-17, 19.

MCM1992 问题-A 空中交通控制雷达的功率问题

要求你决定一个主要城市的机场的空中交通控制雷达发射的功率。机场行政部门希望兼顾安全性与经济性使雷达的发射功率最小。

机场行政部门限于使用现有的天线和接收线路。唯一可以考虑的选择是改进雷达的发射电路使雷达更强大。你要回答的问题是雷达必须发射多少功率(以瓦特为单位)反以保证能探测到 100 公里以内的标准客机。

技术说明：

- ① 雷达天线是一个旋转抛物面的一部分，该抛物面的焦距又 1 米。它投影至与顶点相同的平面是一个长轴为 6 米，短轴为 2 米的椭圆。从焦点发出的主能量束是一个圆锥，其长轴角为 1 弧度，短轴角为 50 毫弧度。天线和能量束的简图如图 92A-1 所示。
- ② 理想化的一类飞机是具有 75 平方米完全雷达反射截面团飞机，亦即在你的初步模型中飞机等价于一个 75 的小圆位于天线轴线上并垂直于该轴的 100% 反射圆碟，你亦可以考虑其它模型或改进这个模型。
- ③ 接收线路的灵敏度是雷达天线反馈报警器(位于雷达天线的焦点)对 10 微瓦的回波信号会作出反应。

MCM 1992 问题-B 应急电力修复系统的修复计划

为沿海地区服务的电力公司必须具备应急系统来处理风暴引起的电力中断。这样的系统需要由估计的修复时间和费用与由客观准则判定的停电的“价值”构成的数据输入，过去 HECO 电力公司曾因缺乏优先方案而遭受传播媒介的批评。

设想你是 HECO 电力公司顾问。HECO 具有一个实时处理的，通常包含下述信息的服

务电话的计算机数据库：

报修时间；需求者类型；估计受害人数；地点(X,Y)。

有两个工程队调度所，分别位于(0,0)和(40,40)，其中 x, y 以英里为单位。HECO 的服务区域在 $-65 < x < 65$ 和 $-50 < y < 50$ 之内。因为该地区完全都市化了，有极好的道路网络。工程队只是在上班和下班时必须回调度所。公司的政策是：若停电的设施是铁路或医院，只要有工程队可派就立即处理，其他情形都要等暴风雨离开这一地区后才开始工作。

HECO 请你为表 92B-1 所列的暴风雨修复请求和表 92B-2 所列的维修能力建立客观准则和安排工作计划。注意，第一个电话是凌晨 4: 20 接到的，暴风雨在上午 6: 00 离开该地区，还要注意很多停电户是当酬反迟才报修的。

HECO 出自自身的目的需要一份技术报告和一份用外行术语写就的“执行简要”来提交新闻媒介。他们希望对将来的建议。为决定你的优先计划安排系统，你还需作一些附加的假设，请详述这些假设。将来你可能希望有附加的数据，如果有，详述这些需要的信息。

MCM1993 问题-A 加速餐厅剩菜堆肥的生成

一家注重环境的学校餐厅正用微生物把顾客没吃完的食物再循环生成堆肥。每天餐厅把吃剩的食物和泥浆(粘结剂)混合，再把它们和厨房里容易弄碎的色拉菜以及少量的扯碎的纸片混合，并把混合物喂给一种真菌培养物和土壤细菌，它们把泥浆、绿叶菜、纸片消化形成有用的塔肥。易碎的绿叶菜为真菌培养物提供氧气，而纸片则吸收过量的湿气。但有时真菌培养物显得不能或不肯消化顾客留下的那么多的剩饭菜。餐厅并没有因为真菌培养物没有胃口而责怪厨师长。餐厅收到要大量购买他们生产的堆肥的报价，所以餐厅正在研究增加堆肥产量的方法。由于无力营建一套新的堆肥设备，因此餐厅首先寻求能加速真菌培养物活力的方法，例如，通过优化真菌培养物的环境(眼下大约是在 120F 和 100%湿度的环境下生成堆肥的)，或通过优化喂给真菌培养物的混合物统成，或同时优化两者(而达到加速真菌培养物的活力)。

试决定在喂给真菌培养物的混合物中泥浆、绿叶菜和纸片印比例与真菌培养物把混合物生成堆肥的速度间是否存在任何关系。若你认为不存在任何关系，试说明理由。否则，试决定什么样的比例会加速真菌培养物的活力。

除了按竞赛规则说明中规定的格式写的技术报告外，请为餐厅经理提供一页长的用非技术术语表示的实施建议。

作为数据，表 93A-1 列出了分别存放在不同的箱子中用磅表示的混合物组成中各种原料的数量，以及把混合物喂给真菌培养物的日期以及完全生成堆肥的日期(以表示生成堆肥所需的时间)。

本题是由东华盛顿大学数学系的 Yves Nievegctlt 提供的，本题叙述的情况及数据来自华盛顿奶 Medical Lake 地区监狱的餐厅。他还写了一篇评论文章 The outstanding optimal composting papers, The UMAP Journal, v.4(1993), no.3, 227-228.

MCM1993 问题-B 倒煤台的操作方案

Aspen-Boulder 煤矿公司经营一个包括一个单个的大型倒煤台在内的装煤设施。当装煤列车到达时，从倒煤台往上装煤。一列标准列车要用 3 小时装满，而倒煤台的容量是一列半标准列车。每天，铁道部门向这个装煤设施发送三列标准列车。这些列车可在当地时间上午 5 点到下午 8 点的任何时间内到达。每列列车有三辆机车。如果一列车到达后因等待装煤而停滞在那里(即处于等待服务状态)的话、铁道部门要征收一种称为滞期费的特别费用、每小时每辆机车 5000 美元。此外，每周星期四上午 11 点到下午 1 点之间有一列大容量列车到达。

这种特殊的列车有五辆机车并能装两列标准列车的煤。一个装煤工作班要用 6 个小时直接从煤矿运煤来把空的倒煤台装满。这个工作班(包括它用的设备)的费用是每小时 9000 美元。可以调用第二个工作班运行一个附加的倒煤台操作系统来提高装煤速度,而费用为每小时 12000 美元,出于安全的原因,当往倒煤台装煤时,不能往列车上装煤。每当由于往倒煤台装煤而中断往列车上装煤时,就要征收滞期费。

煤矿公司的经理部门要请教你们如何决定该倒煤台的装煤操作的午预期开支,你们的分析应包括考虑以下的问题:

- ① 应调用几次第二个工作班?
- ② 预期的月滞期费是多少?
- ③ 如果标准列车能按调度在确切时间到达,什么样的日调度安排能使装煤费用最少?
- ④ 调用第三个费用每小时 12000 美元的倒煤台操作系统工作班,能否降低年操作费用?
- ⑤ 该倒煤台每天能否再装第四辆标准列车的煤?

本题是由位于科罗拉多州 Golden 的科罗拉多矿业学院的 Genc Woolsey 根据他在怀俄明州一家煤矿公司做顾问中的问题建议的。位于纽约州的西点军校的 ChriArney 和 Jack Robertson 据此形成了本问题。

MCM1994 问题-A 住宅的保温

HUP 公司正在考虑建造从单幢住宅到公寓楼大小不同的住宅。公司主要关心的是房主定期支付的费用--特别是暖气和冷气的费用最少。建房地区位于全年温度变化不大的温带地区。

通过特殊的建筑技术 HUP 公司能不依靠对流--即不需要依靠开门开窗--来帮助调节住宅的温度。这些住宅都是只有混凝土厚板地板为仅有基础的单层住宅。你们被雇用为顾问来分析凝土厚板地板小的温度变化,由此决定地板表面的平均温度能否全年保持在指定的舒适范围内。如果可能的话,什么样的尺寸和形状能做到这点?

第一部分地板温度

由表 94A-1 给 G66 每天温度的变化范围,试研究混凝土厚板中温度的变化。假定最高温度在中午达到,最低温度在午夜达到。试决定能否在只考虑幅射的条件下设计厚板使其表面的平均温度保持在指定的舒适范围内。一开始,先假定热是通过暴露在外的厚板的周边传入住宅的,而厚板的上、下表面是绝热的。就这些假设是否恰当、假设的敏感性作山评论。如果你们不能找到满足表 94A-1 条件的解,你们能作出满足你们提出的表 94A-1 的厚板的设计吗?

第二部分建筑物温度

试分析一开始所作假设的实用性,并将其推广到分析单层住宅内温度的变化。住宅内温度能否保持在舒适范围内。

第三部分建筑费用

考虑到建筑的各种限制及费用,试提出一种考虑 HUP 公司关于降低甚至免去暖气和冷气费用这一目标的设计。

MCM 1994 问题-B 计算机网络的最短传输时间

在你们的公司里,各部门每天都要分享信息。这种信息包括前一天的销售统计和当前的

生产指南。尽快公布这些信息是十分重要的。

假设一个通讯网络被用来从一台计算机向另一台计算机传输数据组(文件)。作为例子,考虑下列图 94B-1 模型:

顶点从 v_1 表示计算机, 边 e_{ij} 表示(由边的端点表示的计算机之间)要传输的文件。 t_{ij} 表示传输文件 e_{ij} 所需的时间, c_i 表示计算机 v_i 同时能传输多少个文件的容量。文件传输包括占用有关计算机为传输该文件所需的全部时间。

$c_i = 1$ 表示计算机 v_i 一次只能传输一个文件。

我们感兴趣的是以最优的方式安排传输, 即使得传输完所有的文件所用的总时间最小。这个最小总时间称为接通时间(makespan)。请为你们的公司考虑以下三种情形:

情形 A:

你们公司有 28 个部门。每个部门有一台计算机, 在图 94B-2 中每合计算机用顶点表示。每天必须传输 27 个信息, 在图 94B-2 中用边来表示。对于这个网络, 对所有的 $x, y = 1, \dots, 28$, $c_x = 1$ 。试找出该网络的最优安排以及接通时间。你们能向你们的主管人员证明你们对该网络求得的接通时间是最小可能(最优)的吗?叙述你们求解该问题的方法。你们的方法适用于一般情形吗, 即是否适用干了 c_i 以及图结构都是任意的情形?

情形 B:

假设你们公司改变了传输要求。现在你必须在同样酌基本网络结构(见图 94B-2)上考虑不同类型和大小的文件。传输这些文件所需时间由表 94B-1 中每条边的 t_{ij} 项表出。对所有 y 仍有 $c_y = 1$ 。试对新网络找出最优安排和接通时间, 你们能证明对新网络而言你们求得的最小接通时间是最小可能的吗?叙述你们求解该问题的方法。你们的方法适用于一般情形吗?试对任何特异的或出乎意料的结果发表评论。

情形 C:

你们公司正在考虑扩展业务。如果公司真的这样做的话, 每天有几个新文件(边)要传输。这种业务扩展还边括计算机系统的升级换代。28 个部门中的某些部门将配备新的计算机使之每次能传输不止一个文件。所百这些变化都在下面的图 94B-3 以及表 94B-2, 表 94B-3 中表明。你们能找到的最优安排和接通时间是什么?你们能证明对该网络而言这个接通时间是最小可能的吗?叙述你们求解该问题的方法。试对任何特异的或者出乎意料的结果发表评论。

MCM-1995 问题-A 单一螺旋线

问题为向小型微生物工程公司提供帮助。设计出“实时”求一条螺旋线与空间中位于一般位置的平面(见图 95A-1)所有交点的方法, 证明方法的正确性并编程对算法进行数值检验。在计算机辅助几何设计(CAGD)中用类似程序可使工程人员观察到他们所设计物体的截面, 例如, 飞机引擎, 汽车缓冲装置或者医疗器材等。而且工程设计人员也许还能显示出诸如气流、压力、温度以及用颜色或水平线的编码。进一步地, 工程人员可以运

过对整个物体的截面部分进行快速扫描以得到物体的三维视觉及其运动、受压和受热时的反应。为达此目的, 所用的计算机程序必须以尽可能快的速度和尽可能高的精度找出所需观察平面与所给物体每一部分的所有交点, 一般所指的“问题求解”即为求此类点, 但对特殊问题而言, 特殊方法或许比通用方法更高效更准确。特别地, 通用的计算机辅助几何设计软件或许会由于速度太慢而不能完成实时计算, 或者软件适用范围虽然广泛但并不适合公司所提出的医疗服务要求, 基于上述考虑, 公司提出下列问题。

问题 设计、判断、编程并检验给定平面与螺旋线在空间小任意位置和方向上的交点。例如, 在化学或医疗器械中, 一段螺旋线可表示为直立悬挂的弹簧或一小段钢管。算法理论上的证明需要通过几种不同的角度来进行, 例如, 对算法进行数学上的证明并用已知例子的编程进行检验, 另外, 从事医疗服务的当事人进行检验和证实也是必要的。

MCM1995 问题-B A1uacha Balaclava 学院

A1uacha Balaclava 学院聘用了一个新院长。前任院长是由于教员工资问题而被迫辞职的，因此，新院长需要制定一个公平合理的工资系统方案，以树立其权威。作为第一步，她聘请你们队作为顾问，设计一个能够反映以下背景及原则的工资系统。

背景

教员共分四级：助教、讲师、副教授、教授。博士毕业后任教的教员被聘为讲师。在读的博士生被聘为助教，并且当毕业时自动升为讲师。副教授通常须满七年后才能申报教授。级别晋升由院长及一个教师委员会来决定，你们无须考虑此问题。

教员每年发 10 个月工资：从 9 月到次年 6 月。每次晋级从 9 月起生效。能够用于晋级增加工资的奖金数日每年有所不同，通常需要到 3 月份才能知道确切数。一个没有从教经历的助教及讲师的初始工资分别是 27000 元及 32000 元。一个受聘教员在其他学校的教学经历同样得到承认。

原则

- ①只要资金允许，所有教员工资每年都应增加。
- ②教员应能从晋级中获得充分的利益。如果一名教员在尽可能短的时间内得到晋升，其获得的利益应大致相当于七年增加的工资。
- ③如果一个教员都是正常晋级(在一个级别上工作七、八年)，并且具有 25 年以上的教龄。他退休时的工资应大致相当于一个刚毕业的博士的工资的两倍。
- ④同一级别的教员中经验较丰富的应有较高的工资，但是这种差别应随着时间的推移而逐渐消失。换句话说，如果两个教员级别相同，他们的工资应随着时间的推移而越来越接近。

方案

首先，设计一个不考虑物价增长的新的工资系统，然后再考虑物价增长的情形。本方案最终是要设计一个转移过程，将现有的工资系统过渡到你设计的系统中去，并且不能消减任何人的工资。现有教员的工资、级别及工作年限已列于表 95B-1 中。

院长要求得到一个详尽的工资系统方案，她将以此为据进行工资调整。同时，她还要求得到一份清晰、简短的执行摘要，用于分发给教员及张贴公布。摘要应当概括出模型的轮廓，并介绍它的假设、优缺点及预期结果。

MCM1996 问题-A 噪音场中潜艇的探测

海洋中存在着背景噪音场，地震引起的摄动，海面上航行的船只，以及生活在大海中的哺乳动物都是具有不同频率范围的噪音源。我们要考虑如何利用这种背景噪音测定大的移动目标，例如海面下的潜艇。假定潜艇不产生影响测定的噪音，只利用测量背景噪音场的变化所得到的信息，研制一种能够探测出移动潜艇的存在，并测出它的速度、尺寸及航行方向的方法。从一个固定的频率和振幅的噪音着手进行。

MCM1996 问题-B 竞赛评判问题

在确定像数学建模竞赛这种形式的比赛的优胜者时，常常要评阅大量答卷。譬如说，有 $P=100$ 份答卷，一个由 J 位评团人组成的小组来完成评阅任务，基于竞赛资金对于能够聘请的评阅人数量和评阅时间的限制，如果 $P=100$ ；通常取 $J=8$ 。理想的情况是每个评阅人看所有的答卷，并将它们一一排序，但这种方法工作量太大。另一种方法是进行一系列的

筛选,在一次筛选中每个评阅人只看一定数量的答卷,并给出分数。为了减少所看答卷的数量,考虑如下的筛选模式:如果答卷是被排序的,则在每个评阅人给出的排序中排在最下面的 30%答卷被筛除;如果答卷被打分(譬如说从 1 分到 10 分),则某个截止分数线以下的答卷被筛除。这样,通过筛选的答卷重新放在一起返回给评阅小组,重复上述过程。人们关注的是,每个评阅人看的答卷总数要显著地小于 P 。评阅过程直到剩下 W 份答卷时停止,这些就是优胜者。当 $J=100$ 时通常取 $W=3$ 。

你的任务是利用排序、打分及其它方法的组合,确定一种筛迫模式,按照这种模式,最后选中的 v 份答卷只能来自“最好的” $2W$ 份答卷(所谓“最好的”是指,我们假定存在着一种评阅人一致赞同的答卷的绝对排序)。例如,用你给出的方法得到的最后 3 份答卷将全部包括在“最好的”6 份答卷中。在所有满足上述要求的方法中,希望位能给出使每个评阅人所看答卷份数最少的一种方法。

注意在打分时存在系统偏差的可能。例如,对于一批答卷,一位评阅人平均给 70 分,而另一位可能给 80 分。在你给出的模型中如何调节尺度来适应竞赛参数(P , J 和 W)的变化? 1996 年两道题都是由 Daniel Zwillinger Zwillinger&Associates、Arlington,MA, USA 提供的。

MCM1997 问题-A Velociraptor(疾走龙属)问题

Velociraptor, *Velociraptor mongoliensis* 是生活在距今约 7500 万年前白垩纪(译注:白垩纪为距今 1.36-0.65 亿年的地质年代,是中生代最后的纪)的一种食肉(捕食其他动物的)恐龙。

古生物学家认为这是一种非常顽强的猎食其他动物的野兽,而且可能是成对或成群地外出追猎。然而,不幸的是无法像观察现代哺乳食肉动物在野外是如何追猎其食物的行为那样观察到 Velociraptor 在野外的追猎行为。一组古生物学家来到你们队请求你们在 Velociraptor 的追猎行为的建模方面给予帮助。他们希望把你们的结果与研究狮子、老虎及其他类似的食肉动物行为的生物学家的研究报告相比较。

平均的成年 Velociraptor 长 3 米,髌高 0.5 米,重约 45 公斤。据估计,这种动物跑得非常快,速度可达 60 公里/小时,持续约 15 秒。在以这种速度开始助冲刺后,它要停下来在其肌肉中积聚乳酸以恢复体力。

假设 Velociraptor 捕食一种称为 Thescelosaurus(太西龙属)neglectus 的大小与 Velociraptor 差不多的双足食草动物。从 Thescelosaurus 化石的生物力学分析得知 Thescelosaurus 可以 50 公里/小时的速度长时间奔跑。

第 1 部分

假设 Velociraptor 是一只独居的猎食其他动物的野兽,试设计一个单个的 Velociraptor 潜近猎物并追猎一只单个的 Thescelosaurus 的策略以及被追捕物逃避迟捕的策略的数学模型。假设当 Velociraptor 潜近 15 米内时, Thescelosaurus 总能觉察到,根据栖息地及气候的条件不同,甚至在(多达 50 米的)更大的范围内觉察欲捕食它的动物的存在。此外,由于 Velociraptor 的身体结构及体能,它在全速奔跑时的拐弯半径是受到限制的。据估计,拐弯半径大约是其髌高的三倍。另一方面, Thescelosaurus 却是极其灵活的,其拐弯半径只有 0.5 米。

第 2 部分

更现实地假设 Velociraptor 是成对外出追猎,试设计一个新的关于成对的 Velociraptor 潜近猎物并追猎一只单个的 Thescelosaurus 的策略以及被追捕物逃避追捕的策略的数学模型。利用第 1 部分给出假定和限制

MCM1997 问题-B 为取得富有成果的讨论怎样搭配与会成员

为讨论重要问题,特别是长远规划问题而召开小组讨论会正变得愈来愈普遍。人们相信有很多人参加的会妨碍有成果的讨论,甚至一位占支配地位的人能控制并操纵会议的讨论。因此,在公司的董事会议中在召集全体董事会议之前会先开一些讨论有关事务的小组会议。这些规模较小的小组会议仍然有被某个占支配地位的人控制的危险。为降低这种危险,常用的办法是安排每个小组开几次会,每次会有不同的人参加。

An Tostal 公司的一次会议的参加者为 29 位公司董事会成员,其中 9 位是在职董事(即公司的雇员)。会议要开一天,每个小组上午开 3 段。下午开 4 段。每段会议开 45 分钟,从上午 9:00 到下午 4:00 每整点开始开会,中午 12:00 午餐。上午的每段会议都有 6 个小组讨论会,每个小组讨论会都由公司的一位资深高级职员来主持讨论,这些资深高级职员都不是董事会的成员。因此,每资深高级职员都要主持 3 个不同的小组讨论会。这些资深高级职员不参加下午的讨论会,而且下午的每段会议只有 4 个不同的小组讨论会。

公司董事长要一份公司董事参加 7 段会议的每个小组讨论会酌分配名单。这份搭配名单要尽可能多地把董事均匀搭配。理想的搭配应是每一位董事和其他每一位董事一起参加小组讨论会的次数相同,与此同时要使不同段的小组中在一起开过会的董事数达到最小。

名单中的搭配还应满足下列两个准则:

- ①在上午的讨论会上,不允许一位董事参加由同一位资深高级职员主持的两次会议。
- ②每个分组讨论会都不应有不成比例的在职董事参加。给出一张 1-9 号在职董事、10—29 号董事、1-6 号公司资深高级职员的搭配名单。说明该名单在多大程度上满足了前面提出的各种要求和准则。因为有的董事可能在最后一刻宣布不参加会议,也可能不在名单上的董事将出席会议,因此一个能使秘书在一小时前得到变更与会与否通知的情况下来调整搭配的算法定会得到赏识。如果算法还能用于涉及不同水平的与会者参加的未来的会议中每类与会者搭配的话,那就更理想了。

MCM1998 问题-A 磁共振成像扫描仪

引言

用于工业和医疗的磁共振成像扫描仪诊断机对像脑那样的三维物体进行扫描,并把扫描的结果以三维像素阵列的形式传送之。每个像素由一个指示其颜色或灰度的数构成,它对像素所在位置处的被扫描物体的一个小区域中含水量(浓度)的度量进行编码。例如,0 能以黑色来描绘出高含水量(脑室、血管),128 能以灰色来描绘出中等含水量(脑核和灰质),而 255 以白色来描绘出低含水量(组成有髓体轴的富含脂类白质)。这类磁共振成像扫描仪还包括能在屏幕画出通过该三维像素阵列的平行或垂直片(与三个笛卡尔坐标轴平行的平片)的设备。能够描绘出斜的平片的算法是专卖的。眼下的算法利用了角度及可供使用的参数选择而受到限制,算法的执行也有赖于大量使用专用的工作站;在切片之前缺少在画面上作点的输入能力;从而使原始像素间明晰的边界变得模糊。

能在个人计算机上实现的更为准确可靠的、灵活的算法对于以下几方面来说将是极为有用的:

- ①设计尽可能少的介入处理;
 - ②校准磁共振成像扫描仪;
 - ③研究诸如动物研究中尸体解剖组织部分那样的在空间中斜向的结构;
 - ④能作出以任意角度和由黑白固线组成的脑图谱相交的截面。
- 为设计这样的算法,就要能存取任意像素的值和位置,不仅仅是由扫描仪收集到的原始数据。

问题

设计并测试能产生与三维阵列在空间任意指向的平面的截面部分的算法,并尽可能保持原始的灰度值。

数据集

典型的数据集由表示物体在位置 (i, j, k) 处的浓度的由数 $A(i, j, k)$ 构成的三维阵列 A 典型的情形, $A(i, j, k)$ 的取值范围为 0 到 255. 在大多数应用中, 该数据集是相当大的。参赛队要设计用以测试并论证其算法的数据集。数据集应能反映大概是有诊断意义的情况。参赛队还应叙述限制其算法有效性的数据集的特征。

总结

算法一定要生成由空间一平面与三维阵列相交出的切片部分的图象。这种平面在空间可以钉任意的指向和位置(该平面可能会漏掉一些或全部数据点)。算法的结果应该是所扫描的物体在所选平面上的浓度的一个模型。

MCM1998 问题-B 成绩给分的通胀

背景

一些行政领导很为 A Better class(ABL)学院的成绩给分担忧。平均说来, ABC 学院的教师一直在给高分(现在结出的平均成绩分数为 A^-), 从而不可能区分好学生和中等水平的学生。金额很大的奖学金只能资助班上前 10% 的学生, 因而要对班上的学生排名次。院长有一想法: 把班上每个学生和其他学生进行比较, 并用比较获得的信息来排名次。例如, 若某个学生得分为 A 而全班学生都得 A , 那么这个学生只能属于这个班上的“平均水平”。另一方面, 如果班上只有一个学生得 A , 那么这个学生显然在“平均水平之上”, 结合几门课中得到的比较信息就能把全校的学生按十分位数排名次(前 10%。次 10%, …… , 等等)。

问题

假定给出的成绩记分为 $(A^+, A, A^-, B^+, \dots)$ 院长的想法能否实现?

假定给出的成绩记分只有 (A, B, C, \dots) 院长的想法能否实现?

有没有其他能给出名次排列的方案? 一种担心是, 一个班级的成绩记分可能会改变许多学生的十分位数的排名次。可能出现这种情况吗?

数据集

参赛队要设计用以测试并论证其算法的数据集, 参赛队还应叙述限制其算法有效性的数据集的特征。

MCM1999 问题-A 大碰撞

NASA(航空航天管理局)常常考虑这样一个问题: 一颗较大的小行星与地球的碰撞将会产生怎样的后果。

作为这个问题的一部分, 要求你们讨论这颗小行星该到地球南极所造成的后果, 有人认为其后果将与该行星撞到地球其它区域的后果有很大的不同。

你们可以假设这颗小行星的直径大约为 1000 米, 并且立接撞在南极点处。

你们应当给出这样一次碰撞的后果的估计, 特别地, NASA 希望得到由这次碰撞所造成的人员伤亡的地区及数量的估计, 还希望得到关于对南半球的大洋区域的农作物生长的危害的估计, 以及由于南极冰层大规模融化引起的沿海洪水的一个估计。

MCM1999 问题-B “非法”聚会

许多公共设施的房间都有一种标有人数的记号,当房间中人数超过记号上人数时就视为“非法”,该数目可假定是以紧急情况下从房屋出口逃出的人数为基准确定的,类似地,电梯及其它设施经常有一个“最大容量”。

建立数学模型以确定标上多大人数值才是“合法容量”,作为求解的一部分要讨论若干准则(并非在火灾或其它紧急情况下的公共安全)决定出房屋(或空间)达到“非法”聚会的人数,而且,在所建模型中要考虑几种不同的房屋结构,例如,像咖啡屋(拥有桌和椅子)那样具有可移动家具的房子,具有成排椅子和走廊的演训厅等,你还可以对各种不同情形进行比较与对比,例如:电梯,演讲厅,游泳池,咖啡屋或健身房等。

收集摇滚音乐会或足球比赛的相关资料也许会为你提供一些特殊的信息。将所建模型用于你所在学院(或附近城镇)的一个或多个公共设施中,如果该类设施已标有“合法”人数的话,请将模型所得结果与之比较。如果得到使用,你的模型可能部分受到利益驱动下要增加容量之观点的挑战,为当地报刊撰写一篇文章以捍卫模型所给的分析。

I CM1999 问题-C Ground Pollution

Background

Several practically important but theoretically difficult mathematical problems pertain to the assessment of pollution. One such problem consists in deriving accurate estimates of the location and amount of pollutants seeping inaccessibly underground, and the location of their source, on the basis of very few measurements taken only around, but not necessarily directly in, the suspected polluted region.

Example

A data set is located at: [procddata.xls](#)

The data set (an Excel file which can be downloaded into most spreadsheets) shows measurements of pollutants in underground water from 10 monitoring wells (MW) from 1990 to 1997. The units are micrograms per liter ($\mu\text{g/l}$). The location and elevation for eight of the wells is known and given below. The first two numbers are the coordinates of the location of the well on a Cartesian grid on a map. The third number is the altitude in feet above Mean Sea Level of the water level in the well.

Well Number (ft)	x-Coordinate (ft)	y-Coordinate (ft)	Elevation (ft)
MW-1	4187.5	6375.0	1482.23
MW-3	9062.5	4375.0	1387.92

Well Number (ft)	x-Coordinate (ft)	y-Coordinate (ft)	Elevation (ft)
MW-7	7625.0	5812.5	1400.19
MW-9	9125.0	4000.0	1384.53
MW-11	9062.5	5187.5	1394.26
MW-12	9062.5	4562.5	1388.94
MW-13	9062.5	5000.0	1394.25
MW-14	4750.0	2562.5	1412.00

The locations and elevations of the other two wells in the data set (MW-27 and MW-33) are not known. In the data set you will also see the letter T, M or B after the well number, indicating the measurements were taken at the Top, Middle, or Bottom of the aquifer in the well. Thus, MW-7B and MW-7M are from the same well, but from the bottom and from the middle. Also, other measurements indicate that water tends to flow toward well MW-9 in this area.

Problem One

Build a mathematical model to determine whether any new pollution has begun during this time period in the area represented by the data set. If so, identify the new pollutants and estimate the location and time of their source.

Problem Two

Before the collection of any data, the question arises whether the intended type of data and model can yield the desired assessment of the location and amount of pollutants. Liquid chemicals may have leaked from one of the storage tanks among many similar tanks in a storage facility built over a homogeneous soil. Because probing under the many large tanks would be prohibitively expensive and dangerous, measuring only near the periphery of the storage facility or on the surface of the terrain seems preferable. Determine what type and number of measurements, taken only outside the boundary or on the surface of the entire storage facility, can be used in a mathematical model to determine whether a leak has occurred, when it occurred, where (from which tank) it occurred, and how much liquid has leaked.

MCM2000 问题-A 空间交通管制

为加强安全并减少空中交通指挥员的工作量，联邦航空局(FAA)考虑对空中交通管制系统添加软件，以便自动探测飞行器飞行路线可能的冲突，并提醒指挥员。为完成此项工作，FAA 的分析员提出了下列问题。

要求 A: 对于给定的两架空中飞行的飞机，空中交通指挥员应在什么时候把该目标视为太靠近，并予以干预。

要求 B: 空间扇形是指某个空中交通指挥员所控制的三维空间部分。给定任意一个空间扇形，我们怎样从空中交通工作量的方位来估量它是否复杂？当几个飞行器同时通过该扇形

时,在下面情形所确定的复杂性会达到什么程度:(1)在任一时刻?(2)在任意给定的时间范围内?(3)在一天的特别时间内?在此期间可能出现的冲突总数是怎样影响着复杂性来的?

提出所添加的软件工具对于自动预告冲突并提醒指挥员,这是否会减少或增加此种复杂性?

在作出你的报告方案的同时,写出概述(不多于二页)使 FAA 分析员能提交给 FAA 当局 Jane Garvey, 并对你的结论进行答辩。

MCM2000 问题-B: 无线电信道分配

我们寻找无线电信道配置模型.在一个大的平面区域上设置一个传送站的均衡网络,以避免干扰.一个基本的方法是将此区域分成正六边形的格子(蜂窝状),如图 1.传送站安置在每个正六边形的中心点.

容许频率波谱的一个区间作为各传送站的频率.将这一区间规则地分割成一些空间信道,用整数 $1, 2, 3, \dots$ 来表示.每一个传送站将被配置一正整数信道.同一信道可以在许多局部地区使用,前提是相邻近的传送站不相互干扰.根据某些限制设定的信道需要一定的频率波谱,我们的目标是极小化频率波谱的这个区间宽度.这可以用跨度这一概念.跨度是某一个局部区域上使用的最大信道在一切满足限制的配置中的最小值.在一个获得一定跨度的配置中不要求小于跨度的每一信道都被使用.

令 s 为一个正六边形的一侧的长度.我们集中考虑存在两种干扰水平的一种情况.

要求 A: 频率配置有几个限制,第一,相互靠近的两个传送站不能配给同一信道.第二,由于波谱的传播,相互距离在 $2s$ 内的传送站必须不配给相同或相邻的信道,它们至少差 2.在这些限制下,关于跨度能说些什么.

要求 B: 假定前述图 1 中的格子在各方向延伸到任意远,回答要求 A.

要求 C: 在下述假定下,重复要求 A 和 B.更一般地假定相互靠近的传送站的信道至少差一个给定的整数 k ,同时那些隔开一点的保持至少差 1.关于跨度和关于设计配置的有效策略作为 k 的一个函数能说点什么.

要求 D: 考虑问题的一般化,比如各种干扰水平,或不规则的传送站布局.其他什么因素在考虑中是重要的.

要求 E: 写一篇短文(不超过两页)给地方报纸,阐述你的发现。

ICM 2000 问题-C: Elephants: When is Enough, Enough?

“Ultimately, if a habitat is undesirably changed by elephants, then their removal should be considered -even by culling.” National Geographic (Earth Almanac) –December 1999 A large National Park in South Africa contains approximately 11,000 elephants. Management policy requires a healthy environment that can maintain a stable herd of 11,000 elephants. Each year park rangers count the elephant population. During the past 20 years whole herds have been removed to keep the population as close to 11,000 as possible. The process involved shooting (for the most part) and occasionally relocating approximately 600 to 800 elephants per year.

Recently, there has been a public outcry against the shooting of these elephants. In addition, it is no longer feasible to relocate even a small population of elephants each year. A contraceptive dart, however, has been developed that can prevent a mature elephant cow from conceiving for a period of two years.

Here is some information about the elephants in the Park:

- There is very little emigration or immigration of elephants.
- The gender ratio is very close to 1:1 and control measures have endeavored to maintain parity.
- The gender ratio of newborn calves is also about 1:1. Twins are born about 1.35% of the time.
- Cows first conceive between the ages of 10 and 12 and produce, on average, a calf every 3.5 years until they reach an age of about 60. Gestation is approximately 22 months.
- The contraceptive dart causes an elephant cow to come into oestrus every month (but not conceiving). Elephants usually have courtship only once in 3.5 years, so the monthly cycle can cause additional stress.
- A cow can be darted every year without additional detrimental effects. A mature elephant cow will not be able to conceive for 2 years after the last darting.
- Between 70% and 80% of newborn calves survive to age 1 year. Thereafter, the survival rate is uniform across all ages and is very high (over 95%), until about age 60; it is a good assumption that elephants die before reaching age 70.
- There is no hunting and negligible poaching in the Park.

The park management has a rough data file of the approximate ages and gender of the elephants they have transported out of the region during the past 2 years. This data is available on website: `icm2000data.xls`. Unfortunately no data is available for the elephants that have been shot or remain in the Park.

Your overall task is to develop and use models to investigate how the contraceptive dart might be used for population control. Specifically:

Task 1: Develop and use a model to speculate about the likely survival rate for elephants aged 2 to 60. Also speculate about the current age structure of the elephant population.

Task 2: Estimate how many cows would need to be darted each year to keep the population fixed at approximately 11,000 elephants. Show how the uncertainty in the data at your disposal affects your estimate. Comment on any changes in the age structure of the population and how this might affect tourists. (You may want to look

ahead about 30-60 years.)

Task 3: If it were feasible to relocate between 50 and 300 elephants per year, how would this reduce the number of elephants to be darted? Comment on the trade-off between darting and relocation.

Task 4: Some opponents of darting argue that if there were a sudden loss of a large number of elephants (due to disease or uncontrolled poaching), even if darting stopped immediately, the ability of the population to grow again would be seriously impeded. Investigate and respond to this concern.

Task 5: The management in the Park is skeptical about modeling. In particular, they argue that a lack of complete data makes a mockery of any attempt to use models to guide their decision. In addition to your technical report, include a carefully crafted report (3-page maximum) written explicitly for the park management that responds to their concerns and provides advice. Also suggest ways to increase the park managers confidence in your model and your conclusions.

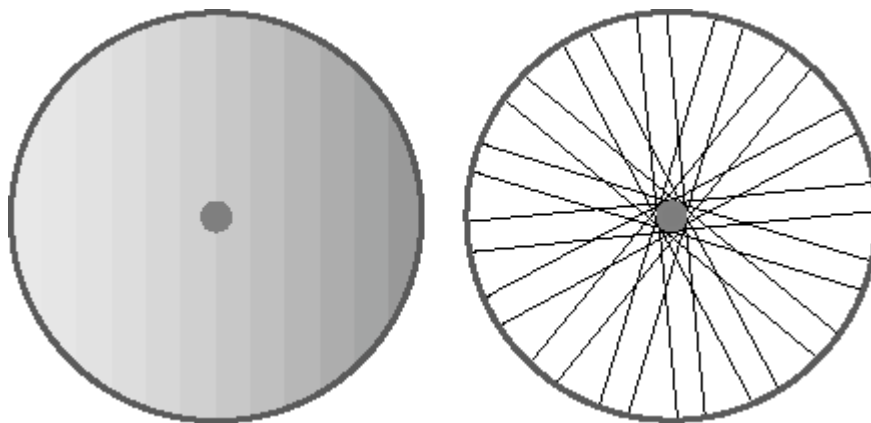
Task 6: If your model works, other elephant parks in Africa would be interested in using it. Prepare a darting plan for parks of various sizes (300-25,000 elephants), with slightly different survival rates and transportation possibilities.

MCM2001 问题- A: 选择自行车车轮

有不同类型的车轮可以让自行车手们用在自己的自行车上。两种基本车轮类型是分别用金属辐条和实体圆盘组装而成（见图 1）。辐条车轮较轻，但实体车轮更符合空气动力学原理。对于一场公路竞赛，实体车轮从来不会用作自行车的前轮但可以用作后轮。

职业自行车手们审视竞赛路线，并且请一位识文断字的人推断应该使用哪种车轮。选择决定是根据沿途山丘的数量和陡度，天气，风速，竞赛本身以及其他考虑作出的。你所喜爱的参赛队的教练希望准备妥当一个较好的系统，并且对于给定的竞赛路线已经向你的参赛队索取有助于确定宜用哪种车轮的信息。

这位教练需要明确的信息来帮助作出决定，而且已经要求你的参赛队完成下面列出的各项任务。对于每项任务都假定，同样的辐条车轮将总是装在前面，而装在后面的车轮是可以选择的。



任务 1. 提供一个给出风速的表格,在这种速度下实体后轮所需要的体能少于辐条后轮。这个表格应当包括相应于从百分之零到百分之十增量为百分之一的不同公路陡度的风速。(公路陡度定义为一座山丘的总升高除以公路长度。如果把山丘看作一个三角形,它的陡度是指山脚处倾角的正弦。)一位骑手以初始速度 45kph 从山脚出发,他的减速度与公路陡度成正比。对于百分之五的陡度,骑上 100 米车速要下降 8kph 左右。

任务 2. 提供一个例证,说明这个表格怎样用于一条时间试验路线。

任务 3. 请判明这个表格是不是一件决定车轮配置的适当工具,并且关于如何作出这个决定提出其他建议。

MCM2001 问题-B 逃避飓风怒吼 (一场恶风...)

1999 年,在 Floyd 飓风预报登陆之前,撤离南卡罗来纳州沿海地区的行动导致一场永垂青史的交通拥塞。车水马龙停滞在州际公路 I-26 上,那是内陆上从 Charleston 通往该州中心 Columbia 相对安全处所的主要干线。正常时轻松的两个小时驱车路要用上 18 个小时才能开到头。许多车竟然沿途把汽油消耗净尽。幸运的是, Floyd 飓风掉头长驱北上,这次放过了南卡罗来纳州,但是,公众的喧嚷正在迫使该州官员们寻找各种办法,以求避免这场交通恶梦再度出现。

倾力解决这个问题的主要提议是 I-26 公路上的车辆转向疏散,因此,包括通往海岸的多条次级公路在内,从两个侧面疏导车流在内陆从 Charleston 开往 Columbia。把提议付诸实施的计划已经由 South Carolina Emergency Preparedness Division 准备好(而且贴在互联网上)。从 Myrtle Beach 和 Hilton Head 通往内地的主干道上车辆转向疏散的方案也在规划中。

这里有一张南卡罗来纳州的简化地图。Charleston 有近 500,000 人, Myrtle Beach 有 200,000 人左右,而另一个 250,000 人分散在沿岸其余地区。(如果查找,更精确的数据随处可用。

州与州之间有两条车辆往来的次级公路,自然大都市地区除外,那里有三条。Columbia, 又一个 500,000 人左右的大都市地区,没有充足的旅店空间为撤退者提供食宿(包括沿其他路线来自大北边的一些人),所以,若干车辆继续撤离,沿着 I-26 公路开往 Spartanburg 市;沿着 I-77 公路北上 Charlotte 市;而且沿着 I-20 公路东进 Atlanta 市。在 1999 年,从 Columbia 开往西北方向的车辆行进得非常慢。对这个问题建立一个模型,调查研究哪种策略可以降低在 1999 年观察到的拥挤。这里有一些问题需要加以考虑:



South Carolina

在什么条件下,把 I-26 的两条开往海岸的次级公路变成开往 Columbia 的两条次级公路,特别是把整个 I-26 变成单行道会使撤离交通状况得到重大改善?

在 1999 年,南卡罗来纳州的整个沿海地区奉命同时撤离。如果采取另一种策略,逐个郡按某个时间段错开撤离,同时与飓风对沿岸影响的模式相协调,撤离交通状况会改善吗?

在 I-26 公路旁边有若干较小的高速公路从海岸延伸到内陆。在什么条件下,把车辆流转向这些道路会改善撤离交通?

在 Columbia 建立更多临时收容所来减少离开 Columbia 的车辆,这会对撤离交通状况有什么影响?

在 1999 年,离开海岸的许多家庭一路上携带他们的船只,露营设备和汽车住宅。许多家庭驾驶他们的所有汽车。在什么条件下,应当对携带的车辆类型或车辆数目加以限制以求保证适时撤离?

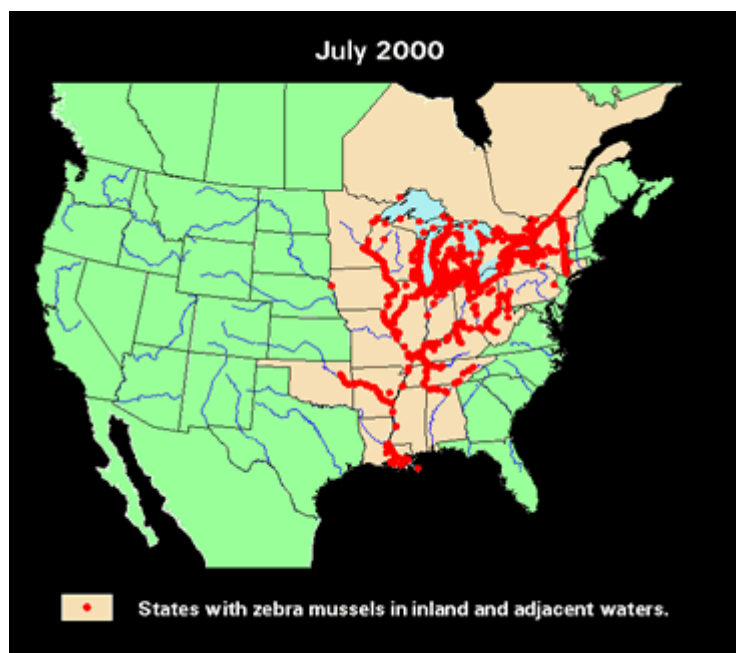
在 1999 年,人们还会记得,若干 Georgia 州 and Florida 州的沿岸居民逃避较早预报的 Floyd 飓风南部登陆,沿着 I-95 公路北上而加重了南卡罗来纳州交通问题。他们对于撤离交通的冲击会有多大?

要清楚地指明,为了比较各种策略,使用什么方法对实施状况予以评测。

要求:预备一篇简短的报刊文章,不超过两页,向公众解释你的研究成果和结论。

ICM2001 问题-C 我们的水系-不确定的前景

2001 ICM: Our Waterways - An Uncertain Future



Zebra mussels, *Dreissena polymorpha*, are small, fingernail-sized, freshwater mollusks unintentionally introduced to North America via ballast water from a transoceanic vessel. Since their introduction in the mid 1980s, they have spread through all of the Great Lakes and to an increasing number of inland waterways in the United States and Canada. Zebra mussels colonize on various surfaces, such as docks, boat hulls, commercial fishing nets, water intake pipes and valves, native mollusks and other zebra mussels. Their only known predators, some diving ducks, freshwater drum, carp, and sturgeon, are not numerous enough to have a significant effect on them. Zebra mussels have significantly impacted the Great Lakes ecosystem and economy. Many communities are trying to control or eliminate these aquatic pests. SOURCE: Great Lakes Sea Grant Network <http://www.sgnis.org/>.

Researchers are attempting to identify the environmental variables related to the zebra mussel infestation in North American waterways. The relevant factors that may limit or prevent the spread of the zebra mussel are uncertain. You will have access to some reference data to include listings of several chemicals and substances in the water system that may affect the spread of the zebra mussel throughout waterways. Additionally, you can assume individual zebra mussels grow at a rate of 15 millimeters per year with a life span between 4 - 6 years. The typical mussel can filter 1 liter of water each day.

Requirement A: Discuss environmental factors that could influence the spread of zebra mussels.

Requirement B: Utilizing the chemical data provided

at: <http://www.comap/undergraduate/contests/icm/imagesdata/LakeAChem1.xls>, and the mussel population data provided

at: <http://www.comap/undergraduate/contests/icm/imagesdata/LakeAPopulation1.xls> model the population growth of zebra mussels in Lake A. Be sure to review the Information about the collection of the zebra mussel data.

Requirement C: Utilizing additional data on Lake A from another scientist provided at <http://www.comap/undergraduate/contests/icm/imagesdata/LakeAChem2.xls> and additional mussel population data provided at <http://www.comap/undergraduate/contests/icm/imagesdata/LakeAPopulation2.xls> corroborate the reasonableness of your model from Requirement B. As a result of this additional data, adjust your earlier model. Analyze the performance of your model. Discuss the sensitivity of your model.

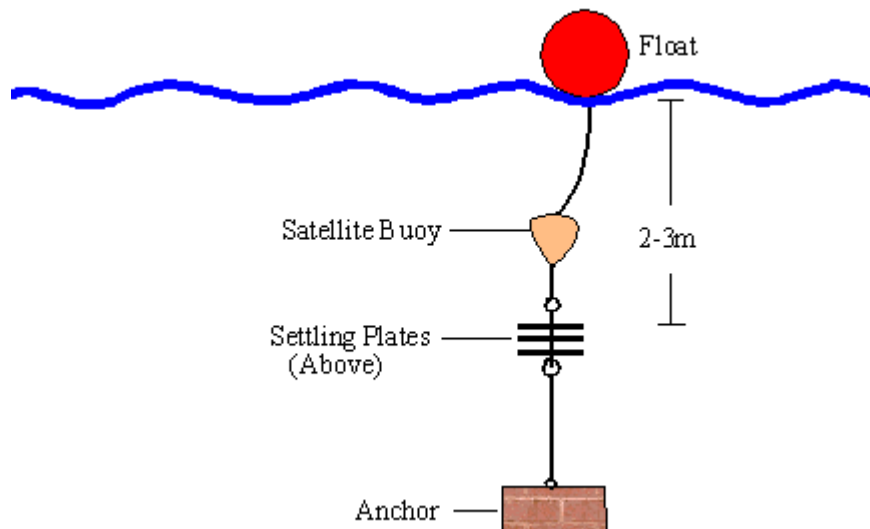
Requirement D: Utilizing the Chemical data from two lakes (Lake B and Lake C) in the United States provided at <http://www.comap/undergraduate/contests/icm/imagesdata/LakeB.xls> and <http://www.comap/undergraduate/contests/icm/imagesdata/LakeC.xls> determine if these lakes are vulnerable to the spread of zebra mussels. Discuss your prediction.

Requirement E: The community in the vicinity of Lake B (in requirement D) is considering specific policies for the de-icing of roadways near the lake during the winter season. Provide guidance to the local government officials regarding a policy on “de-icing agents.” In your guidance include predictions on the long-term impact of de-icing on the zebra mussel population.

Requirement F: It has been recommended by a local community in the United States to introduce round goby fish. Zebra mussels are not often eaten by native fish species so they represent a dead end ecologically. However, round gobies greater than 100 mm feed almost exclusively on zebra mussels. Ironically, because of habitat destruction, the goby is endangered in its native habitat of the Black and Caspian Seas in Russia. In addition to your technical report, include a carefully crafted report (3-page maximum) written explicitly for the local community leaders that responds to their recommendation to introduce the round goby. Also suggest ways to help reduce the growth of the mussel within and among waterways.

Information about the collection of the zebra mussel data

The developmental state of the Zebra mussel is categorized by three stages: veligers (larvae), settling juveniles, and adults. Veligers (microscopic zebra mussel larvae) are free-swimming, suspended in the water for one to three weeks, after which they begin searching for a hard surface to attach to and begin their adult life. Looking for zebra mussel veligers is difficult because they are not easily visible by the naked eye. Settled juvenile zebra mussels can be felt on smooth surfaces like boats and motors. An advanced zebra mussel infestation can cover a surface, even forming thick mats sometimes reaching very high densities. The density of juveniles was determined along the lake using three 15×15 cm settling plates. The top plate remained in the water for the entire sampling season (S - seasonal) to estimate seasonal accumulation. The middle and bottom plates are collected after specific periods (A – alternating) of time denoted by “Lake Days” in the data files.



The settling plates are placed under the microscope and all juveniles on the undersides of the plate are counted and densities are reported as juveniles/m².

MCM2002 问题-A 风和喷水池

在一个楼群环绕的宽阔的露天广场上，装饰喷泉把水喷向高空。刮风的日子，风把水花从喷泉吹向过路人。喷泉射出的水流受到一个与风速计（用于测量风的速度和方向）相连的机械装置控制，前者安装在一幢邻近楼房的顶上。这个控制的实际目标，是要为行人在赏心悦目的景象和淋水浸湿之间提供可以接受的平衡：风刮得越猛，水量和喷射高度就越低，从而较少的水花落在水池范围以外。

你的任务是设计一个算法，随着风力条件的变化，运用风速计给出的数据来调整由喷泉射出的水流。

MCM2002 问题-B 航空公司超员订票

你备好行装准备去旅行，访问 New York 城的一位挚友。在检票处登记之后，航空公司职员告诉说，你的航班已经超员订票。乘客们应当马上登记以便确定他们是否还有一个座位。航空公司一向清楚，预订一个特定航班的乘客们只有一定的百分比将实际乘坐那个航班。因而，大多数航空公司超员订票？也就是，他们办理超过飞机定员的订票手续。而有时，需要乘坐一个航班的乘客是飞机容纳不下的，导致一位或多位乘客被挤出而不能乘坐他们预订的航班。

航空公司安排延误乘客的方式各有不同。有些得不到任何补偿，有些改订到其他航线的稍后航班，而有些给予某种现金或者机票折扣。

根据当前情况，考虑超员订票问题：

航空公司安排较少的从 A 地到 B 地航班

机场及其外围加强安全性

乘客的恐惧

航空公司的收入迄今损失达数千万美元

建立数学模型，用来检验各种超员订票方案对于航空公司收入的影响，以求找到一个最优订票策略，就是说，航空公司对一个特定的航班订票应当超员的人数，使得公司的收入达到最高。确保你的模型反映上述问题，而且考虑处理“延误”乘客的其他办法。此外，书写一份简短的备忘录给航空公司的 CEO（首席执行官），概述你的发现和分析。

MCM2002 问题-C：灌木蜥蜴

如果我们过分扫荡自己的土地，将会失去各种各样的蜥蜴。

佛罗里达灌木蜥蜴是一种灰色或灰褐色小蜥蜴，遍布于佛罗里达中部和大西洋沿岸地区的沙质高地上。Florida 濒危动植物委员会把这种灌木蜥蜴归类为濒危的生物。

在网址 <http://www.comap.com/undergraduate/contests/icm/2002problem/scrublizard.pdf> 你将会找到一份有关这种佛罗里达灌木蜥蜴的实情说明。

佛罗里达灌木蜥蜴的长期存活，有赖于保留适当的空间搭配和灌木丛生地带的规模。

任务 1: 讨论在佛罗里达州促使灌木蜥蜴丧失适当栖息地的各种因素。为了保留这些栖息地，你会提出哪些建议？并且论述实现你的建议的各种障碍。

Year	Age	Total Number Living	Number of Living Females	Avg. Female Size (mm)
1	0	972	495	30.3
2	1	180	92	45.8
3	2	20	11	55.8
4	3	2	2	56.0

任务 2: 利用表 1 中提供的数据估计数值 F_a （成年蜥蜴平均产卵量）； S_j （处在出生和第一个繁殖季节之间的幼年蜥蜴存活率）； S_a （成年蜥蜴平均存活率）。

表 1

摘要数据是关于一群灌木蜥蜴的，它们先被捕捉后连续跟踪四年。幼小蜥蜴（0 岁）在出生当年夏季不产卵。所有其他雌蜥蜴的平均产卵量与身体尺寸成比例，正如线性函数 $y=0.21*(SVL)-7.5$ 所表示的，其中 y 是产卵量，而 SVL 是鼻子到肛门以 mm 为单位的长度。

年度 年龄 存活总数 雌蜥蜴存活数 平均雌蜥蜴身长 (mm)

任务 3: 人们推测，参数 F_a ， S_j 和 S_a 与一片灌木地带的露天沙质区的规模和总量有关联。利用提供在表 2 中的数据构造若干函数来针对不同地带估计 F_a ， S_j 和 S_a 。此外，构造函数对给定地带评估其承载灌木蜥蜴的能力 C 。

表 2

关于 8 个灌木地带的摘要数据，包括灌木蜥蜴的生命变化速率。对于每个地带，雌蜥蜴的年产卵量 (F_a)，幼小蜥蜴存活率 (S_j)，以及成年蜥蜴存活率 (S_a)，连同地带规模和露天沙质栖息地的总量列在一起。

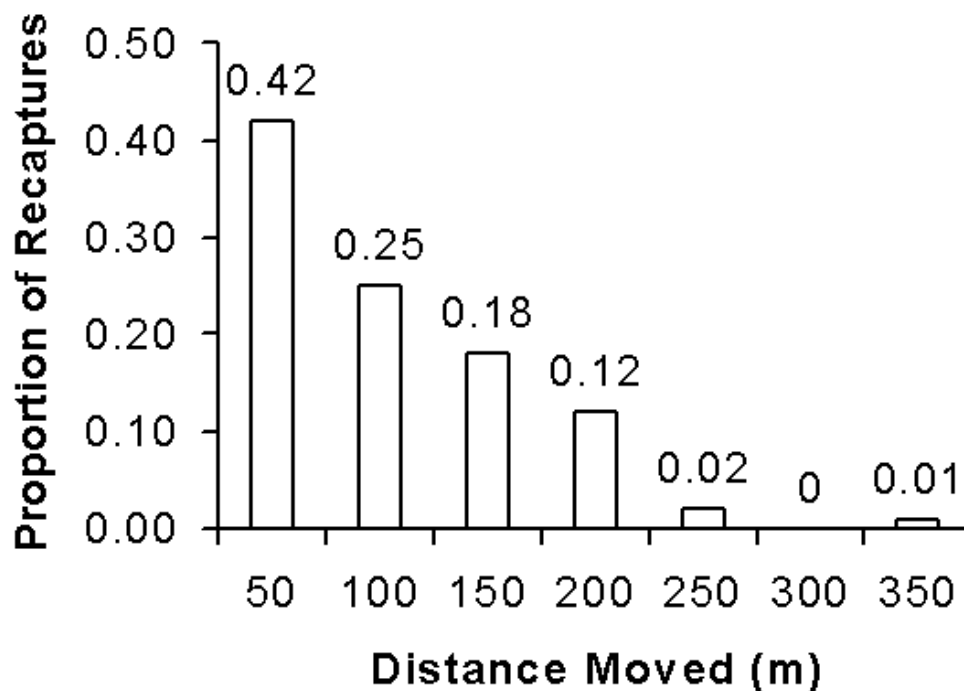
Patch	Patch Size (ha)	Sandy Habitat (ha)	F_a	S_j	S_a	Density (lizards/ha)
a	11.31	4.80	5.6	0.12	0.06	58
b	35.54	11.31	6.6	0.16	0.10	60

Patch	Patch Size (ha)	Sandy Habitat (ha)	Fa	Sj	Sa	Density (lizards/ha)
c	141.76	51.55	9.5	0.17	0.13	75
d	14.65	7.55	4.8	0.15	0.09	55
e	63.24	20.12	9.7	0.17	0.11	80
f	132.35	54.14	9.9	0.18	0.14	82
g	8.46	1.67	5.5	0.11	0.05	40
h	278.26	84.32	11.0	0.19	0.15	115

任务 4: 已有许多动物研究表明, 在一个栖息地带中, 食物, 空间, 掩蔽地, 抑或繁殖配偶可能受限制的, 这就导致动物个体在各个地带之间迁徙。有关灌木蜥蜴的迁徙原因缺少明确的证据。不过, 确有百分之十的幼年蜥蜴在各个地带之间游走, 而这种迁徙会影响一个地带中群体规模。成年蜥蜴显然不迁徙。利用下面直方图中给出的数据估计在任何两个地带 i 和 j 之间经迁徙而存活的蜥蜴的概率。

表 3 直方图

幼年蜥蜴的迁徙数据, 是经由个体标记, 释放, 再捕获直到 6 个月后获取的。对于再捕捉的测量工作是在距离释放地点方圆 750m 内进行。



任务 5: 对于表 3 中给出的地表形貌, 建立模型估计灌木蜥蜴的整个群体规模。而且, 确定哪些地带适于灌木蜥蜴栖息, 哪些地带会不支持一个有生存力的群体。

对于一个展布在 Avon Park Air Force Range 上面的具有 29 个地带的地表形貌, 下面的表格列出了各个地带规模和露天沙质栖息地。参看: <http://www.comap.com/undergraduate/contests/icm/2002problem/map.jpg> 给出的一张地表形貌的地图。

Patch Identification	Patch Size (ha)	Sandy Habitat (ha)
----------------------	-----------------	--------------------

Patch Identification	Patch Size (ha)	Sandy Habitat (ha)
1	13.66	5.38
2	32.74	11.91
3	1.39	0.23
4	2.28	0.76
5	7.03	3.62
6	14.47	4.38
7	2.52	1.99
8	5.87	2.49
9	22.27	8.44
10	19.25	7.58
11	11.31	4.80
12	74.35	19.15
13	21.57	7.52
14	15.50	2.82
15	35.54	11.31
16	2.93	1.15
17	47.21	10.73
18	1.67	0.13
19	9.80	2.23
20	39.31	7.15
21	2.23	0.78
22	3.73	1.02
23	8.46	1.67
24	3.89	1.89
25	1.33	1.11
26	0.85	0.79
27	8.75	5.30
28	9.77	6.22

Patch Identification	Patch Size (ha)	Sandy Habitat (ha)
29	13.45	4.69

任务 6: 空中摄影业已确定, 在佛罗里达灌木区域内, 植被密度一年增长 6% 左右。请针对一个可控燃烧政策提出建议。

MCM2003 问题-A: 特技演员

影片在拍摄中, 一个激动人心的动作场景将要摄入镜头, 而你是特技协调员! 一位特技演员驾驶着摩托车跨越一头大象, 随后跌落在借以缓冲的一堆纸箱上。你需要保护特技演员, 而且, 也要使用相对而言较少的纸箱 (较低的花费, 不能进入镜头, 等等)。

你的工作如下:

确定所用纸箱的大小?

确定所用纸箱的数目?

确定纸箱的堆放办法?

还请确定, 通过对纸箱的各种调整, 是否会有所帮助?

请把你的研究推广到不同组合重量 (特技演员 & 摩托车) 和不同跨越高度的情形留心一下, 在影片“明日帝国”中, 角色 James Bond 驾驶着摩托车飞过一架直升机。

MCM2003 问题-B: Gamma 刀治疗方案

立体定位放射外科, 用单一高剂量离子化射束在 X 光机精确界定下照射颅内的一个小的 3D 脑瘤, 与此同时, 并没有处方剂量的任何显著份额伤及周边的脑组织。在这个领域中, 一般有三种形式的射束可以采用, 分别是 Gamma 刀单元, 带电重粒子射束, 以及来自直线加速器的外用高能光子束。

Gamma 刀单元具备的单一高剂量离子化射束, 是 201 个钴-60 单位源通过厚重的盔状物发射出来的。所有的 201 条射束同时交会于一个等中心(最大放射剂量点), 从而在有效剂量的水平上形成一个近似球形的剂量分布。照射这个等中心来达到处方剂量称为一个“shot”。

多个 shot 可以表述为不同的球。四个可以互换的外部校准的盔状物分别具有 4, 8, 14 和 18mm 的射束通道直径, 都可以用来照射不同尺寸的体积。对于大于一个“shot”的目标体积, 可以用多个 shot 来覆盖整个目标。实际上, 大多数目标体积要用 1 到 15 个“shot”加以处理。在这里, 目标体积是一个有界的通常包含数百万个点的三维数字图象。

放射外科学的目的是消除肿瘤细胞同时保存正常的结构。由于治疗过程中会涉及物理限制和生物不确定性, 一个治疗方案就需要考虑到所有那些限制和不确定性。一般而言, 一个最优的治疗方案需要符合如下的要求:

? 穿过目标体积的剂量梯度最小

为目标体积配置特异性的相同剂量轮廓线?

为目标和关键器官配置特异性的剂量-体积限制条件?

? 对正常组织或器官的整个体积照射要剂量总和最小

对指定的正常组织点的剂量要限制在忍耐剂量以下?

使关键体积所需的最大剂量达到最小?

在 Gamma 单元治疗方案中, 有以下限制:

禁止“shot”伸展到目标以外?

禁止“shot”交迭（避免热点）？

？用有效的剂量覆盖尽可能多的目标体积，但至少 90% 目标体积要被“shot”覆盖

用尽可能少的“shot”？

你的任务是用球体填充问题模型来建立最优的 Gamma 刀治疗方案，并且提出一个求解的算法。在设计算法时你要记住：它必须是相当有效率的。

MCM2003 问题-C 航空行李的扫描对策

2003 ICM: Aviation Baggage Screening Strategies: To Screen or Not to Screen, that is the Question

You are an analysis team in the Office of Security Operations for the Transportation Security Administration (TSA), responsible for the Midwest Region of the United States. New laws will soon mandate 100% screening of all checked bags at the 429 passenger airports throughout the nation by explosive detection systems (EDSs; see Figure 1). EDSs use computed tomography (CT) technology to scan checked bags, similar to how CAT scans are used in hospitals. Using multiple x-rays of each bag, EDSs create three-dimensional images of a bag's content, showing the density of each item. This information is utilized to determine whether an explosive device is present. Experimentation with EDSs indicate that each device is operational about 92% of the time and each device can examine between 160 and 210 bags per hour.

The TSA has been actively purchasing EDSs and deploying them at airports throughout the nation. Given that these devices cost nearly \$1 million each, weigh as much as eight tons, and cost several thousand dollars to install in an airport, determining the correct number of devices to deploy at each airport and how to best use them (once operational) are important problems.

Currently, manufacturers are not able to produce the expected number of EDSs required to meet the federal mandate of 100% screening of checked luggage. Because of the limited number of EDS machines available, the Director of Airport Security for the Midwest Region (Mr. Sheldon) is not surprised that the TSA is requesting a detailed analysis on the estimated number of EDSs required at all airports. In addition, given the limited space and funds available for each airport, Mr. Sheldon believes that at some point a detailed analysis of emerging technologies will be needed. Promising technologies with more modest space and labor costs will emerge in the coming decade (e.g. x-ray diffraction; neutron-based detection; quadropole resonance; millimeter wave imaging; and microwave imaging).

Task 1: You have been tasked by your Director, Mr. Sheldon, to develop a model to determine the number of EDSs required at two of the largest facilities in the region, Airports A & B, which are described in the Technical Information Sheet (TIS)—Appendix A. Carefully describe the assumptions that you make in designing the model, then use your model to recommend the number of EDSs required using the data provided in Table 1 of the TIS.

Task 2: Prepare a short (one page) position paper to accompany your model that describes the security-related objectives of the airlines and the constraints that the airlines must work within for the sets of flights described in Table 1 of the TIS.

Task 3: Since security screening takes time and might delay passengers, the airport managers at Airports A & B request that you develop a model that can help the airlines determine how to schedule the departure of different types of flights within the peak hour. Carefully describe all the assumptions that you make in designing the model and use your model to produce a schedule for the two airports with the data provided in Table 1.

Task 4: Based on your analysis, what can you recommend to Mr. Sheldon and the airlines about checked baggage screening for the flights during the peak hours at your two airports?

Task 5: Mr. Sheldon realizes that your work may have national impact and requests that you write a memo explaining how your models can be adapted to determine the number of EDSs and airline scheduling for all 193 airports in the Midwest Region. He will send the memo along with the models and the analysis to the Director of the Office of Security Operations (his boss) at the TSA and to all security directors of other airports in the region for their comment and possible implementation.

Additional security measures associated with higher risks may require that up to 20% of the passengers will need to have all their checked bags screened through both an EDS and an explosive trace detection (ETD) machine, even though an EDS is 98.5% accurate in identifying explosive devices in checked bags. ETD machines use mass spectrometry technology to detect minute particles of explosive compounds. Each ETD machine costs \$45,000 to purchase, however, the labor cost to operate the ETD machine is approximately 10 times that of the EDS. ETD can process 40 to 50 bags per hour; they are operational 98% of the time, and they are 99.7% accurate in identifying explosive materials on checked bags. At this time, ETD machines have not been federally certified, but Mr. Sheldon believes that they will soon be an integral part of national airport security systems.

Task 6: Modify your EDS models to incorporate the use of ETD machines and determine how many ETD machines are needed for Airports A & B and if the schedules need to be changed. Since this information may affect national level decisions, write a memo to the Director of Homeland Security and the Director of TSA with a technical analysis of this enhanced screening policy. Is the cost of such a policy justified in light of the value that it provides? Should the ETDs replace any of the EDS devices?

Task 7: The Director of Homeland Security must also decide how to best fund future scientific research programs. Use your EDS/ETD model to examine the possible effect of changes in the device technology, cost, accuracy, speed, and operational reliability. Include recommendations for the science, technology, engineering, and mathematics (STEM) research areas that will have the biggest impact on security system performance. Add your recommendation to the memo prepared in Task 7.

Appendix A Technical Information Sheet (TIS)

Table 1 Peak Hour Flight Departures for Airports A and B Note: On average, 2% of flights are cancelled each day

Flight Type	Number of Seats on Each Flight	Airport A Number of Flights of Each Type	Airport B Number of Flights of Each Type
1	34	10	8
2	46	4	6
3	85	3	7
4	128	3	5
5	142	19	9
6	194	5	10
7	215	1	2
8	350	1	1

Although all the flights in Table 1 depart during a peak hour, their actual departure times are set by the airline when designing their flight schedule. A flight cannot depart until all its checked bags are screened using an EDS. The airline has the flexibility to schedule their flights during the peak hour to avoid undesirable flight delays due to unscreened bags.

Historical data indicates that flights with 85 or fewer seats typically fly with between 70% and 100% of their seats occupied. Flights with between 128 and 215 seats typically fly with between 60% and 100% of their seats occupied. Flights with 350 seats typically fly with between 50% and 100% of their seats occupied. Passengers typically arrive for their flight between forty-five minutes and two hours prior to their scheduled departure time. For flights other than “shuttle” service, airlines claim that 20% of the passengers do not check any luggage, 20% check one bag, and the remaining passengers check two bags.

Preliminary estimates indicate that it will cost \$100,000 to modify existing infrastructure (reinforced flooring, etc.) to install each EDS at Airport A and \$80,000 to install each EDS at Airport B.



MCM2004 问题-A: 指纹是独一无二的吗?

人们普遍认为世界上每一个活人的指纹都是不一样的, 请设计一个模型, 并且用该模型分析以上说法正确的可能性, 比较一下因为指纹相同导致确认身份时产生错误的可能性和因为 DNA 相同导致产生错误的可能性。

MCM2004 问题-B: 更快的快通系统

现在的快通系统在收费站、娱乐公园和其他的地方, 正在被越来越频繁的使用, 来减少人们排队等候的时间, 现在我们考虑为一个娱乐公园所设计的快通系统, 在一次测试当中, 这个公园在几个游客比较多的景点旁边都设置了快通系统, 这个系统的设计创意是对于那些比较热门的景点, 可以到旁边的一个机器, 将门票插入后出来一张纸条, 上面写着在具体的时间段你可以回来, 比如说你把你的门票在 1: 15 查到机子里, 系统就告诉你你可以在 3: 30—4: 30 回来, 这个时候队伍就比较短, 你可以凭你的纸条加入这个队伍, 很快就可以进入景点, 为了防止游客同时在几个景点使用这个系统。系统的机器只允许你一次在一个景点排队等待。

现在你是几个被公园雇佣的相互竞争的一个, 你的职责是改善快通系统的运行。很多游客都在抱怨测试期间系统的异常现象, 比如说有一次系统提供的回到景的时间是 4 小时以后, 但是才过一小会, 在相同的景点系统提供的时间只有 1 小时。在另外一些时候根据快通系统组织起来的游客的等候队伍, 就和普通的队伍一样长一样慢。

现在的问题是要提出并且测试一个模型, 这个模型能让快通系统的等候纸条的发放能增加人们在公园的乐趣的目的。问题的一部分就是首先要决定衡量不同模型的标准, 在你提交的报告里还要附带一份非技术性的总结, 以便公园的领导, 在不同的顾问所提的模型当中选择。

MCM2004 问题-C 安全与否?

To Be Secure or Not to Be?

You probably know about computer hackers and computer viruses. Unless your computer has been targeted by

one, you may not know how they could affect an individual or an organization. If a computer is attacked by a hacker or virus, it could lose important personal information and software.

The creation of a new university campus is being considered. Your requirement is to model the risk assessment of information technology (IT) security for this proposed university. The narrative below provides some background to help develop a framework to examine IT security. Specific tasks are provided at the end of this narrative.

Computer systems are protected from malicious activity through multiple layers of defenses. These defenses, including both **policies** and **technologies** (Figure 1), have varying effects on the organization's risk categories (Figure 2).

Figure

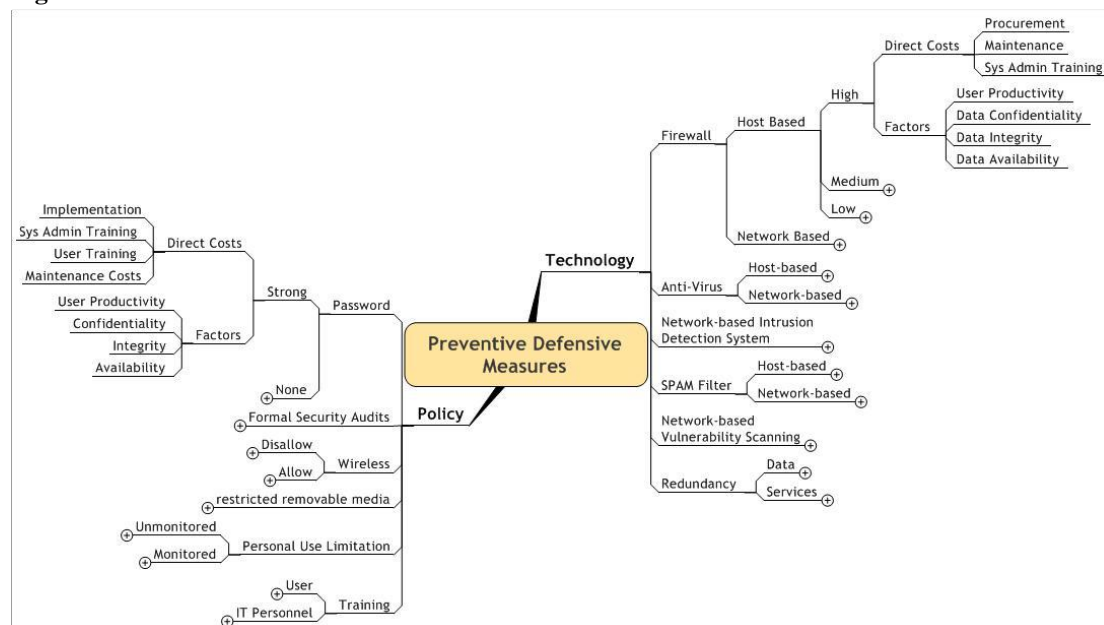


Figure 1 – Preventative Defensive Measures

Management and usage policies address how users interact with the organization’s computers and networks and how people (system administrators) maintain the network. Policies may include password requirements, formal security audits, usage tracking, wireless device usage, removable media concerns, personal use limitations, and user training. An example password policy would include requirements for the length and characters used in the password, how frequently they must be changed, and the number of failed login attempts allowed. Each policy solution has direct costs associated with its implementation and factors that impact productivity and security. In Figure 1, only the topmost branch is fully detailed. The structure is replicated for each branch.

The second aspect of a security posture is the set of technological solutions employed to detect, mitigate, and defeat unauthorized activity from both internal and external users.

Technology solutions cover both software and hardware and include intrusion detection systems (IDS), firewalls, anti-virus systems, vulnerability scanners, and redundancy. As an example, IDS monitors and records significant events on a specific computer or from the network examining data and providing an “after the fact” forensic ability to identify suspect activity. SNORT (www.snort.org) is a popular IDS solution. Figure 1 provides a sample of key defensive measures (management/usage policies and technology solutions). As with a policy, a technology solution also has direct costs, as well as factors that impact productivity and security.

Sources of risk to information security include, but are not limited to, people or hardware within or outside the organization (Figure 2). Different preventive defensive measures (Figure 1) may be more effective against an insider threat than a threat from a computer hacker. Additionally, an external threat may vary in motivation, which could also indicate different security measures. For example, an intruder who is trying to retrieve proprietary

data or customer databases probably should be combated much differently from an intruder who is trying to shut down a network.

Potential costs due to information security that an organization may face (Figure 2) include opportunity cost, people, and the cost of preventative defensive measures. Significant opportunity costs include: litigation damages, loss of proprietary data, consumer confidence, loss of direct revenue, reconstruction of data, and reconstruction of services. Each cost varies based on the profile of the organization. For example, a health care component of the university might have a greater potential for loss due to litigation or availability of patient medical records than with reconstruction of services.

Figure

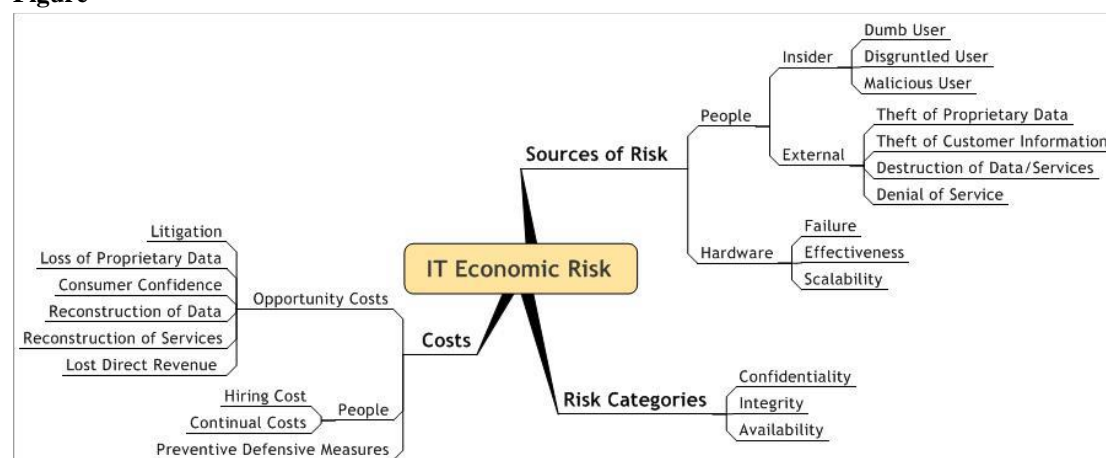


Figure 2 - Economic Risk schematic for IT systems

An organization can evaluate potential opportunity costs through a risk analysis. Risks can be broken down into three risk categories; *confidentiality*, *integrity*, and *availability*. Combined, these categories define the organization's security posture. Each of the categories has different impacts on cost depending on the mission and requirements of the organization. *Confidentiality* refers to the protection of data from release to sources that are not authorized with access. A health care organization could face significant litigation if health care records were inadvertently released or stolen. The *integrity* of the data refers to the unaltered state of the data. If an intruder modifies pricing information for certain products or deletes entire data sets, an organization would face costs associated with correcting transactions affected by the erroneous data, the costs associated with reconstructing the correct values, and possible loss of consumer confidence and revenue. Finally, *availability*

refers to resources being available to an authorized user, including both data and services. This risk can manifest itself financially in a similar manner as confidentiality and integrity

Each measure implemented to increase the security posture of an organization will impact each of the three risk categories (either positively or negatively). As each new defensive security measure is implemented, it will change the current security posture and subsequently the potential opportunity costs. A complicated problem faced by

organizations is how to balance their potential opportunity costs against the expense of securing their IT infrastructure (preventative defensive measures).

Task 1: You have been tasked by the Rite-On Consulting Firm to develop a model that can be used to determine an appropriate policy and the technology enhancements for the proper level of IT security within a new university campus. The immediate need is to **determine an optimal mix of preventive defensive measures that minimizes the potential opportunity costs along with the procurement, maintenance, and system administrator training costs** as they apply to the opening of a new private university. Rite-On contracted technicians to collect technical specifications on current technologies used to support IT security programs. Detailed technical data sheets that catalog *some* possible defensive measures are contained in Enclosures A and B. The technician who prepared the data sheets noted that as you combine defensive measures, the cumulative effects within and between the categories confidentiality, integrity, and availability cannot just be added.

The proposed university system has 10 academic departments, a department of intercollegiate athletics, an admissions office, a bookstore, a registrar's office (grade and academic status management), and a dormitory complex capable of housing 15,000 students. The university expects to have 600 staff and faculty (non IT support) supporting the daily mission. The academic departments will maintain 21 computer labs with 30 computers per lab, and 600 staff and faculty computers (one per employee). Each dorm room is equipped with two (2) high speed connections to the university network. It is anticipated that each student will have a computer. The total computer requirements for the remaining department/agencies cannot be anticipated at this time. It is known that the bookstore will have a Web site and the ability to sell books online. The Registrar's office will maintain a Web site where students can check the status of payments and grades. The admissions office, student health center, and the athletic department will maintain Web sites.

The average administrative employee earns \$38,000 per year and the average faculty employee earns \$77,000 per year. Current industry practice employs three to four system administrators (sys admin) per sub-network and there is typically one (1) sys admin (help desk support) employee per 300 computers. Additionally, each separate system of computers (for web hosting or data management) is typically managed by one (1) sys admin person.

The current opportunity cost projection (due to IT) with no defensive measures is shown in Table 1. The contribution of various risk categories

(Confidentiality Integrity, and Availability) to a given cost is also shown in Table 1.

Table 1: Current Opportunity costs and Risk Category contributions

Opportunity Cost (due to IT)	Amount	Risk Category Contribution
Litigation	\$3,800,000	C (55%), I (45%)
Proprietary Data loss	\$1,500,000	C (70%), I (30%)
Consumer confidence	\$2,900,000	C (40%), I (30%), A (30%)
Data Reconstruction	\$400,000	I (100%)
Service Reconstruction	\$80,000	I (100%)
Direct Revenue Loss	\$250,000	I (30%), A (70%)

Task 2: We know that technical specifications will change rapidly over time. However, the

relations and interplay among costs, risk categories, and sources of risk will tend to change more slowly. **Create a model for the problem in Task 1 that is flexible enough to adapt to changing technological capabilities and can be applied to different organizations.**

Carefully describe the assumptions that you make in designing the model. In addition, provide an example of how the university will be able to use your model to initially determine and then periodically update their IT security system.

Task 3: Prepare a three page position paper to the university President that describes the strengths, weakness, and flexibility of your model in Task 2. In addition, explain what can be inferred and what should not be inferred from your model.

Task 4: Explain the differences that may exist in the initial Risk Category Contributions (Table 1) if you model IT security for a commercial company that provides a search engine for the World Wide Web (such as Google, Yahoo, AltaVista, ...). **Will your model work** for this type of organization?

Task 5: Honeynets are designed to gather extensive information on IT security threats. **Write a two-page memo** to your supervisor advising whether a university or a search engine company should consider using a honeynet.

Task 6: To become a leader in IT security consulting, Rite-On Consulting must also take an active role in anticipating the future direction of information technology and advising companies on how to respond to future security risks. After performing your analysis, **write a two-page memo** to the President of Rite-On to inform him of the future of IT security. In addition, describe how your model can be used to anticipate and respond to the uncertain future.

MCM2005 问题 A.水灾计划

南卡罗来纳州中部的磨累河是由北部的一个巨大水坝形成的，这是在 1930 年为了发电而修建的，模拟一起洪水淹没下游的事件，这起事件是由于一次灾难性的地震损毁了水坝造成的。

两个问题：

Rawls Creek 是水坝下游流入 Saluda 河的一条终年流动的河流，则当水坝损毁后在 Rawls Creek 将会出现多大的洪流，洪水的波及面将有多大？

S.C.国会大厦大楼在一座小山上，在 S.C.国会大厦大楼能俯视 Congaree 河。洪水能如此巨大顺流以致于水将扩展到 S.C.国会大厦大楼吗？

MCM2005 问题 B 收费亭

像 Garden State Parkway, Interstate 95 等等这样的长途收费公路，通常是多行道的，被分成几条高速公路，在这些高速公路上每隔一定的间隔会设立一个通行税收费广场。因为征收通行税通常不受欢迎，所以应该尽量减少通过通行税收费广场引起的交通混乱给汽车司机带来的烦恼。通常，收费亭的数量要多于进入收费广场的道路的数量。进入通行税收费广场的时候，流到大量收费亭的车辆呈扇形展开，当离开通行税收费广场的时候，车流将只能按照收费广场前行车道路的数量排队按次序通过！从而，当交通是拥挤的时，拥挤在违背通行税广场上增加。当交通非常拥挤的时候，因为每车辆付通行费的时间要求，阻塞也会出现在通行税收费广场的入口处。

建立一个模型来确定在一个容易造成阻塞的通行税收费广场中应该部署的最优的收费亭的数量。需要保证每一个进入收费广场的交通线路上都仅有一个收费亭。与当今的实践相比较，在什么条件下这或多或少有效？注意：“最佳”的定义由你自己决定。

MCM2005 问题 C：不可再生的资源

2005 ICM: Nonrenewable Resources

Select a vital nonrenewable or exhaustible resource (water, mineral, energy, food, etc.) for which your team can find appropriate world-wide historic data on its endowment, discovery, annual consumption, and price.

The modeling tasks are:

Using the endowment, discoveries, and consumption data, model the depletion or degradation of the commodity over a long horizon using resource modeling principles.

Adjust the model to account for future economic, demographic, political and environmental factors. Be sure to reveal the details of your model, provide visualizations of the model's output, and explain limitations of the model.

Create a fair, practical “harvesting/management” policy that may include economic incentives or disincentives, which sustain the usage over a long period of time while avoiding severe disruption of consumption, degradation or rapid exhaustion of the resource.

Develop a “security” policy that protects the resource against theft, misuse, disruption, and unnecessary degradation or destruction of the resource. Other issues that may need to be addressed are political and security management alternatives associated with these policies.

Develop policies to control any short- or long-term “environmental effects” of the harvesting. Be sure to include issues such as pollutants, increased susceptibility to natural disasters, waste handling and storage, and other factors you deem appropriate.

Compare this resource with any other alternatives for its purpose. What new science or technologies could be developed to mitigate the use and potential exhaustion of this resource?

Develop a research policy to advance these new areas.

MCM2006 问题 A: 用于灌溉的自动洒水器的安置和移动调度

有各种各样的技术可以利用在灌溉领域。技术范围从先进的滴水系统到周期性淹灌系统。其中有一种常被使用在较小农场的“手移动”灌溉系统：带着洒水喷头的轻质铝管横贯田地，通过周期性的手动移动来保证整块田地都能得到充足的水分。这种类型的灌溉系统相对于其它系统来说，价格更加便宜且更容易维护。特别是它还比较灵活，可以在各种各样的田地或庄稼地使用。它的缺点在于，需要很多的时间和精力来移动灌溉设备并且需要按照规则的间隔进行设备的安装。

假设使用这种类型的灌溉系统灌溉一块 80X30 米的矩形田地，该怎样配置可以使得灌溉时间最少？为完成这项工作，您需要找到一个灌溉算法使得灌溉时间最少，要求灌溉系统仅有一个农夫来维护。田地里经常会使用管子组。您应该确定喷头的数量和喷头之间的间距，并且您应该制定一张管子移动的日程表，其中包括要移动到的具体位置。

管子组是由一些可以连成一条直线的水管组成的。每个管子内径 10 cm，带有一些内径 0.6 cm 可转动的喷嘴，管子 20 米长。水源地的水压是 420 千帕斯卡，流速是每分钟 150 公升。田地的水量每小时不超过 0.75 cm，并且每 4 天至少需 2 厘米的水。水应该尽可能被用。

注意里面几根管子连接在一起一共是 20 米，翻译的时候由于仓卒翻译有问题！

MCM2006 问题 B: 通过机场的轮椅

在航空旅行中有一件令人头疼的事，那就是旅途中需要通过多个机场，并且每次中转都要求旅客换乘另外一架飞机。对于一些行走不便的旅客来说走到另一架飞机的候机室是非常困难的。航空公司解决这种问题的一个简单方法是为那些需要帮助的旅客提供轮椅和一名伴游。这需要对旅客的情况有所了解，但这一点在旅客在机场登记的时候是做不到的。很多情况下，航空公司是在飞机在机场着陆的时候才得到通知的。

航空公司一直希望降低费用开销。轮椅价格昂贵且比较容易破损，需要经常维护。并且雇用伴游也需要费用。为了保证有需要的旅客在飞机着陆后能够及时得到服务，伴游和轮椅必须经常在机场附近备用。在一些大型机场，横穿机场的时间也是相当可观的。轮椅必须被存放在某处，但在机场空间是非常昂贵且有限的。并且将轮椅放在高交通区带来的风险如同推着它们到处移动一样。费用中最大的要数某个旅客由于没有伴游帮助耽误了登机使得飞机无法

起飞带来的费用。后者的费用更加棘手，因为它将直接导致航空公司的平均飞行延迟增加，最终使得一些潜在的顾客放弃选择航空。

Epsilon 航空公司要求第三方帮助他们进行对保留和维护轮椅和伴游的问题和费用的一个详细的分析。航空公司需要制定一个全天使用的、比较经济的轮椅的调度方案。并且需要短期和长期的费用预算。

Epsilon 航空公司对这个问题公开招标解决。您的标书应该包括对情况的概要和分析。包括对于伴游和轮椅的全天运动的详细调度算法。目标是尽可能地降低总成本。为了确保您能中标。您必须通过一些有力的实例来说明您的解答是最佳，并且说明它能够适应大机场使用，适应各种各样的环境。

您的标书应该包括算法在大型(至少 4 个广场)，中型(至少二个广场)，小型(一个广场) 机场的使用实例，其中需要包括在人流量高峰和普通时的情况。您应该说明所有的潜在费用并说明它们各自的关键性比重。标书中还要涉及当旅客中有很大比例的老人或需要帮助的人的情况，他们通常需要花费更多的时间来换机。您的报告还应该涉及为了适应未来的发展需要应该出现的潜在费用和投入。

MCM2006 问题 C：抗击艾滋病的协调

HIV/AIDS₂(人体免疫缺损病毒/艾滋病)的大范围流行已经进入第25 年，由于这种疾病导致的感染人数和死亡人数一直在不断上升。尽管已经付出了巨大的努力，但是我们的国际社会对怎样最有效地分配资源来抗击这种流行病仍然心中无数。

₂ HIV, Human Immunodeficiency Viruses, 人体免疫缺损病毒; AIDS, Acquired Immune Deficiency Syndrome, 获得性免疫缺损综合症, 简称艾滋病或爱滋病。——译注。

你们是联合国的一个专家组，就怎样管理可利用的资源来抗击HIV/AIDS 向联合国提出建议。你们的工作就是要对令人关注的几种方案进行建模，并用你们的模型就资金分配提出建议。下面的说明提供了某些背景资料，也概述了特定的任务。

任务1: 在每个大洲(非洲、亚洲、欧洲、北美洲、澳洲和南美洲)选择一个你们认为在HIV/AIDS 方面是最严重的国家。建立模型来粗略估计这些国家在没有任何其他的干预时从2006 年到2050 年HIV/AIDS感染人数的变化率。确切地解释你们的模型以及作为你们的模型的基础的那些假设。另外，解释一下你们是如何选择要对之进行建模的国家的。

作为你们的分析中要包括的一组国家，请利用附件中的电子数据表中的国家，该表包括直到2003 年的世界卫生组织(WHO)所有成员的名单。

数据:“list_WHO_member_states.xls”₃

有关由国家给出的HIV 流行率的可靠数据一般难以得到。所附的电子数据表包括你们也许可以用于你们的分析中的几个工作数据表。

数据:“hiv_aids_data.xls”

a. “Global HIV-AIDS cases, 1999”: 这些数据来自 UNAIDS(关于HIV/AIDS 的联合国联合课题组),它们报告了1999 年底由国家提供的0 到49 岁HIV 检验为阳性的估计人数。

b. “HIV-AIDS in Africa over time”: 这些数据来自美国政府，它们给出了分开的时间段上有关某些非洲国家城市地区育龄妇女中随时间推移的HIV 流行率的数据。

c. “HIV-AIDS subtypes”: 这些数据来自 UNAIDS，它们给出了按国家的HIV-1 子类型的地区分布。

附件中还有可以为你所用的某些基本人口数和人口统计学数据。

数据:

(1) “fertility_data.xls”：这些数据来自联合国，它们给出了主要的地区、行政区和国家1995-2050

特定年龄的人口出生率(每千名妇女生育子女的数目)

a. 1995-2005 的估计数

b. (在中等生育率的假设下) 2005-2050 的预测数

(2) “**population_data.xls**”: 这些数据来自联合国, 它们给出了主要的地区、行政区和国家(不分性别的) 1950-2050 每年的总人口数(单位: 千)

a. 1950-2005 的估计数

b. (在中等生育率的假设下) 2006-2050 的预测数

(3) “**age_data.xls**”: 这些数据来自联合国, 它们给出了5 年年龄组、主要的地区、行政区和国家(不分性别以及分性别的) 1950-2050 的人口数(单位: 千)

a. 1950-2005 的估计数

b. (在中等生育率的假设下) 2010-2050 的预测数

(4) “**birth_rate_data.xls**”: 这些数据来自联合国, 它们给出了主要的地区、行政区和国家 1950-2050 粗略的出生率 (出生人数/每千人)

a. 1950-2005 的估计数

b. (在中等生育率的假设下) 2005-2050 的预测数

(5) “**life_expectancy_0_data.xls**”: 这些数据来自联合国, 它们给出了主要的地区、行政区和国家在1950-2050 出生 (不分性别以及分性别的) 的人的预期寿命(年)

a. 1950-2005 的估计数

b. (在中等生育率的假设下) 2005-2050 的预测数

有几种HIV/AIDS 专款可以直接给予的方式介入 — 包括预防介入(志愿的咨询和检测服务、避孕套的社会营销、以学校为基础的艾滋病教育、防止母-婴传染的药物, 等等)以及治疗介入(治疗其他未经治疗的性传染病、治疗机会致病的感染, 等等). 你们应该专注于两个可能的介入: 抗逆转录酶病毒(*antiretrovirus*)₃ 选做C 题, 需要利用本问题所给的很多数据, 它们往往是用所附电子数据表的形式给出的. 下同. — 译注.

ARV)药物治疗的准备⁴以及可能会有预防HIV/AIDS 疫苗的准备.

任务2: 首先, 对你们在任务1 中选择的国家, 从2006 到2050 年按年评估你们实际上期望得到的可以用于抗击HIV/AIDS的来自国外捐赠人资助的资金水平. 然后, 对下面三种方案的符合实际的假设下, 利用你们在任务1 中研制的模型以及这些资金资源的估计, 评估你们选定的国家2006-2050 年HIV/AIDS 感染人数预期的变化率:

(1) Antiretroviral (ARV)药物治疗

(2) 预防性HIV/AIDS 疫苗

(3) 同时采用ARV 准备和预防性HIV/AIDS 疫苗

假设上述三种方案都不会有出现HIV 抗药菌株的风险(你们将在任务3 中考察这个问题).

务必仔细地描述作为你们模型的基础的假设.

你们可以选择在收支取舍点、疾病负担等的基础上对任务1 中选定的所有国家或部分国家执行上述三种方案. 如果你们想要的话, 附件是一个可以利用的有关各国收入水平数据的电子数据表.

数据: “**income_data.xls**” 这些数据来自世界银行(2002), 它们给出了在你们的分析中可以自由利用的按人口平均计算的国民生产总值(GNP)以及一般的收入分类⁵.

ARV 药物治疗因其可以延长HIV/AIDS 感染者的生命带来极大的福音. 在富裕国家, ARV 药物使得很大比例的HIV/AIDS 感染者免于死亡, 政策制订者和国际组织正面临怎样增加贫穷国家的HIV/AIDS 感染者获得ARV 药物的途径的巨大政治压力. 低收入国家的卫生保健预算非常有限, 看来贫穷国家不大可能利用他们自己的资源对大多数人口成功地开展这些防治计划. 附件1 给出了来自UNAIDS 对一些国家当前使用ARV 药物治疗的具体的国家的数据.

ARV 的疗效在很大程度上依赖于能否坚持医疗制度及严格的监督. 最获好评的ARV 治疗条件是具有广泛咨询和医生护理的井井有条的计划, 以及定期的检查以监视病情的发展以及机会感染⁶的发病. 不能坚持或者不恰当的治疗会导致两方面的严重后果. 首先, 对接受治疗的个人治疗可能没有效果. 其次, 部分的或是不恰当的治疗被认为会直接导致HIV 抗药性菌株的出现.

一开始用于治疗病人的药物价格已经降到每个病人每年几百美元, 但分发这些药物、提供必要的辅助医疗保健措施以及进一步的治疗是考验政府的行政和财政能力的关键. 据估计, 应用意欲使出现抗药性菌株的可能性最小的临床推荐的方法(DOTS, 或者直接观察短疗程治疗)

来购买和发放ARV 药物的成本会低于每人每年1100 美元. (Adams, Gregor et al. [2001].

“Consensus Statement on Antiretroviral Treatment for AIDS in Poor Countries,”

http://www.hsph.harvard.edu/bioethics/pdf/consensus_aids_therapy.pdf)

对于预防性HIV 疫苗, 请对(除了你们可能已经选来包括在你们模型中的其它因素以外的)以下情况做出你们认为合理的假设:

(1) 预防性HIV/AIDS 疫苗可以投入实用的年份

(2) 多快的疫苗接种率有可能达到以下的疫苗接种的稳定水平:

a. 如果你们希望使新的一群人(幼儿)得到免疫, 那么就假设按国家的新的人群的稳定接种水平就是WHO(2002)报告的白喉-百日咳-破伤风疫苗第三剂(DTP3)的免疫率

i 数据: “vaccination_rate_data.xls”

b. 如果你们希望使成人(5 岁以上的人群)得到免疫, 那么就假设年龄较大人群的稳定接种水平就是WHO(2002)报告的破伤风类毒素第二剂(TT2)的免疫率⁴ 逆转录酶病毒(retrovirus), 是一种病毒, 大多数会产生含有核糖核酸和逆转录酶的肿瘤, 包括引起爱滋病的病毒. 抗逆转录酶病毒药物(antiretrovirus drug). — 译注.

⁵ 世界银行的收入分类(2002): (a) 低收入: 按人口平均计算GNP 小于等于760 美元; (b) 低中等收入: 按人口平均计算GNP 761 - 3030 美元; (c) 高中等收入: 按人口平均计算GNP 3031 - 9360 美元; (d) 高收入: 按人口平均计算GNP 大于等于9361 美元. — 译注.

⁶ 机会感染 (opportunistic infection) 也有人称为条件性感染, 指在人体免疫系统受伤而导致抗感染能力降低的条件下, 本来栖居于人体但未致病的菌群可以变成致病微生物, 所引起的感染. — 译注.¹³

i 数据: “vaccination_rate_data.xls”

(3) 疫苗的功效及其有效期

(4) 是否存在来自疫苗接种的流行病学的外部偶然因素

(5) 假设疫苗是三剂的(three-dose), 而且可以加进疫苗的标准封装随着WHO 的免疫扩展计划(EPI)一起以另外0.75 美元的增加成本发放.

任务3: 考虑以下关于ARV 抗药性菌株的研制的假设, 重新阐明你们在任务2 中研制的三个模型.当前的评估表明, 采用ARV 治疗的病人的坚持程度低于90%-95%的话, 有产生抗药性菌株的“巨大危险”. 在你们的分析中可以采用假设: 接受ARV 治疗的病人的坚持程度低于90%, 就有5%的可能性产生对抗标准的一线药物治疗的HIV/AIDS 菌株产生抗药性.人们也可以使用二线和三线药物治疗但在你们的分析中应假设, 要在欧洲、日本和美国以外的国家要使用这些药物将会是昂贵得负担不起的.

任务4: 向联合国写一份白皮书, 就如下问题提出你们专家组的建议:

(1) 就抗击HIV/AIDS 中ARV 药物的供应和预防性HIV 疫苗的可利用资源的分配提出建议

(2) 相对于其他外交政策的优先性而言, 你们关于怎样权衡作为国际关心的HIV/AIDS 的重要性的论证

(3) 你们对怎样协调捐赠人对HIV/AIDS 的介入的建议

对于问题(1), 假设从现在起到2010 年期间, 可利用的财政资源的分配能加速预防性HIV 疫苗的研制工作 — 或直接资助疫苗的研发(R&D), 或通过其他的机制来实现这个目的. 花费这种资助的任何收获都将把你们在任务2 中假设的研制日期提早实现.

附件1. 接受ARV 药物治疗的晚期HIV 感染的成人的百分比(略)

MCM2007 问题-A:不公正划分选区

地区歧视美国宪法规定,美国众议院应由若干(目前是 435)来自各个国家的人当选该州的人口比例相对于整个国家。虽然这提供了一种方法确定有多少每个国家都有代表,它说什么如何区由一个特定的代表地理位置决定。这种疏忽导致严重的(至少有些人是这样认为的,通常不是现任)区形状看起来“不自然”的标准。

因此以下问题:假设你是有机会吸引国会选区的状态。你将如何做一个纯粹的“基线”运动创建“简单”形状的所有地区国家?规则只包括各地的国家必须包含相同的人口。“简单”的定义是你,但你需要做出一个令人信服的论点在该州选民,你的解决方案是公平的。作为一个应用程序的方法,绘制地理上简单的纽约州的国会选区。

MCM2007 问题-B 飞机座位的问题

航空公司可以自由座位乘客等待登上一架飞机在任何顺序。它已经成为习惯的座位乘客有特殊需要第一,紧随其后的是头等舱乘客(他坐在飞机前部)。然后教练和商务舱乘客坐在组行,从行开始后面的飞机,继续前进。

除了考虑乘客的等待时间,从航空公司的角度来看,时间就是金钱,和登机时间是最好的最小化。航空公司的飞机赚钱只在运动时,和长时间寄宿限制飞机旅行的数量可以在一天。大飞机的发展,如空客 A380(800 人次),突出的问题最小化登机(在)时间。设计和比较登机,并与不同数量的乘客在飞机:小(85 - 210),中型(210 - 330),大(450 - 800)。准备一份执行摘要,不超过两页双倍行距,你出发得出结论的航空公司高管的观众,门代理,和飞行人员。

一篇文章刊登在《纽约时报》11 月 14 日,2006 年解决程序目前被跟踪,对航空公司找到更好的解决方案的重要性。本文可以看到

:<http://travel2.nytimes.com/2006/11/14/business/14boarding.html>

ICM2007 问题-C 器官移植:肾交换问题

移植网络: 尽管在医学和卫生技术的持续和显着的进步,对器官的需求急剧移植超过捐助者的数量。为了帮助这种情况下,美国国会通过了国家器官移植法在 1984 年,建立了器官获取和移植网络 (OPTN), 器官捐赠者匹配患者的器官需要。即使这一切组织的技术和到位的的服务,有近 94,000 移植候选人,在美国等待器官移植,这个数字预计将超过 100,000 很快。平均等待时间超过 3 年双,在某些领域,如大城市。器官移植是无论是从尸体队列或从活体捐赠者获得。为有效利用尸体队列的键是整个网络的合作和良好的沟通。好消息是,该系统运行正常,而且越来越多的捐助者(活着的和已故)被确定,并与移植每月发生的创纪录的数字,每年使用。坏消息是,候选列表的增长越来越长。有人认为现行制度,区域和国家层面正走向崩溃与相应的故障对一些最贫穷的病人。此外,基本的问题是:能否这一网络得到改善,我们如何提高一个复杂的网络状 OPTN 的成效? 不同的国家有不同的流程和政策,这些工作最好? 当前系统的未来地位是什么?

任务 1: 对于一个起始参考,请阅读 OPTN 网站 (<http://www.optn.org>) 与它的政策说明和数据银行 (<http://www.optn.org/data> 和 <http://www.optn.org/latestData/viewDataReports.asp>) 。构建通用的美国移植网络 (次) 的数学模型。这种模式必须能够深入了解以下内容: 哪里可以找到有效的器官匹配的潜在瓶颈? 如果有更多的资源可用于提高供体匹配过程的效率,在那里和他们怎么可能被使用? 将这个网络发挥更好的作用,如果它是 (在州一级的实例) 分成更小的网络? 最后,可以通过让大家保存和延长生命更系统更

有效呢？如果是这样，建议政策变化和修改模型，以反映这些改进。

任务 2：调查的移植政策比美国以外的国家使用。从任务 1 修改你的模型，确定是否美国的政策会被通过实施在对方国家使用的过程改进。作为一个专家分析团队（的公共卫生问题和网络科普知识）成员受雇于国会来执行对这些问题的研究，写一页纸的报告向国会处理任务 1 和信息和可能的改进的问题和事项你发现你从不同的国家的政策研究。一定要参考你如何从任务 1 用你的模型来帮助解决问题。

专注于肾交易所：肾脏过滤血液，排除废物，使激素和产生尿液。肾功能衰竭可以通过许多不同的疾病和病症引起的。人终末期肾病面对死亡，透析（在超过 60000 美元/年），或希望为肾脏移植。一个可移植来自一个人的谁同意死后或从活体捐献器官的尸体。在美国，约有 68,000 名患者正在等待从死者捐赠肾脏，而每年只有 10,000 个来自个人的生活（通常是病人的亲属）的尸体和 6000 移植。因此，平均等待匹配肾为三年，不幸的是，一些有需要的病人也不能存活足够长的时间来接受肾。

有参与收件人的肾移植，整体身体和心理健康的许多问题，收件人（保险移植及术后用药），和捐助可用性的财务状况（是否有活体捐赠者愿意提供一个肾）。移植肾必须是相容的 ABO 血型。的 5 年存活率的移植是通过最大限度地减少错配的上血液中的 6 HLA 标记物的数量增加。每年至少有 2000 would-be-donor/recipient 对被挫败，因为血液型不兼容或较差的 HLA 匹配。其他来源表明，超过 6000 人目前的轮候名单上有一个愿意，但不相容的捐赠者。这是一个显著的损失捐助人口和值得考虑制定新的政策和程序时。

起源于韩国的想法是，肾脏交换系统，它可以发生任何与活体或尸体队列。一个交换配对捐肾，其中每两个病人都有一个愿意捐助谁是不相容的，但每个捐赠者与其他患者的兼容；每个捐赠者捐赠给其他患者，通常在同一天，同一家医院。另一个想法是成对列表的捐赠，其中自愿捐助，代表一个特定的病人，捐赠给另外一个人等待尸体肾；作为回报，捐助门诊对病人接受更高的优先级为一个兼容的肾脏从尸体队列。然而，第三个想法是扩大配对的肾脏捐赠给 3 路，4 路，或圆（正成对），其中每个捐赠者给予绕了一圈下一个病人。2006 年 11 月 20 日，12 位外科医生进行的 firstever 5 路肾脏互换约翰霍普金斯医疗设施。没有预期的供受体移植的人，因为捐赠者与原来预定的接收者之间不兼容的可能。在任何给定时间，有许多患者供体对（也许多达 6,000）具有不同的血型和 HLA 标记。同时，尸体队列接收肾脏每天和每天被清空的分配是由和移植进行。

任务 3：设计一个程序，以最大限度地提高交流的数量和质量，同时考虑到形势的医疗和心理动态。证明在什么样的方式你的程序达到最大。估计你的程序将要多年度移植产生，并在轮候名单上所产生的影响。

策略：患者可能面临痛苦的选择。例如，假设 HLA 不匹配肾的勉强兼容，在条件变为可从尸体队列。如果他们要么接受，要么等待一个更好的匹配从尸体队列或从交易所？特别是，尸体肾脏具有较短的半衰期比活体供肾。

任务 4：制定一项战略，为病人，以决定是否采取提供肾脏，或甚至参与肾脏交换。考虑风险，替代品，并在分析概率。

道德问题：移植与涉及平衡什么是最适合的社会，什么是最适合个人技术和政治问题的一个有争议的问题。标准已经发展得非常仔细，以尽量确保人们在轮候名单上得到公平的对待，和几个政策试图解决谁应该去到列表或谁应该脱落的伦理问题。参与获取或脱落列表标准可以包括恶性疾病，HIV 感染或艾滋病患者，严重心脑血管疾病，不遵守事先处理，或控制不佳的精神病病史的诊断。在确定优先安置使用的标准包括：时间在轮候名单上，供体和受体之间的匹配质量，捐赠者和接受者之间的物理距离。由于近期政策变化的结果，未满 18 岁的子女获得优先轮候名单上，并经常接受数周或数被列入名单个月内移植。美国器官共享网络网站最近（2006 年 10 月 27 日）显示，等待患者的年龄：

在 18 : 748 18 到 34 : 8,033 35 至 49 : 20,553 50 至 64 : 28,530 65 岁及以上: 10,628 持续关注的一个伦理问题是重点和优先年龄的增加通过捐赠节省整体生活的时间量。从统计学的角度来看,因为年龄似乎是最重要的因素在预测的存活时间,一些人认为肾脏是被浪费在旧的收件人。

政治问题:移植系统的区域化已经产生政治后果(例如,有人可能迫切需要一个肾,是相当高的队列,但他或她的已故邻居的肾脏仍然可以去一个酒鬼毒贩 500 英里以外的一大市)。医生住在小社区,谁不想做好的移植,这样做每年的移植数量最少需要持续的经验。然而,从这些小社区的肾脏经常去的医院在大城市,因此,当地的医生也无法保持自己的水平。这就提出了一个问题,应该只在少数大型器官移植中心进行,由少数专家和有经验的外科医生?请问这是一个公平的制度,将其添加或从系统效率的减损?

许多其他的伦理和政治问题正在讨论。目前的一些政策,可以发现网址为: [:/ / www.unos.org/policiesandbylaws/policies.asp?resources=true](http://www.unos.org/policiesandbylaws/policies.asp?resources=true) 例如,最近的法律已经获得通过,在美国,禁止销售或强制捐赠器官,但很多机构倡导捐助者收到他们的器官的经济补偿。伊利诺伊州有一个,它假定每个人都希望成为器官捐赠者(假定同意),人们必须退出,如果他们不这样做的新政策。预计卫生和人类服务部的咨询委员会器官移植建议所有国家采取捐赠器官假定同意的政策。在新的国家政策的最终决定权在卫生资源和服务管理卫生和人类服务部美国之内。

任务 5 : 根据你的分析,你推荐的任何更改这些标准和政策?讨论你的建议交换过程的伦理问题和建议您耐心策略(任务 3 和 4)。排名顺序,你会使用优先级和安置,如上,与理由,为什么你每次放置在您做的标准。你会考虑让人们卖器官移植?写 onepage 纸到美国卫生资源和服务管理处处长的建议。

任务 6 : 从潜在的捐赠者的角度来看,风险志愿参与评估的收件人成功的概率,对捐赠者的生存概率,为捐助者将来的健康问题的可能性,未来的健康风险(如概率剩下的一个肾)的失败,术后疼痛和恢复。如何这些风险及其他影响捐赠者的决定?如何感知风险和个人问题(恐惧症,非理性的恐惧,误传,以往的经验与手术,利他主义的水平,和信任程度)影响捐赠的决定?如果输入列表成对网络而不是直接移植到亲戚或朋友,请问正成对网络的大小为 n 对潜在捐赠者的决定有什么影响?可以将您的模型进行修改,以反映和分析这些问题?最后,提出如何发展和招募更多的利他捐赠者。

MCM2008 问题 A:给大陆洗个澡

研究一下由于全球气温升高造成的北极冰帽融化对大陆的影响。具体来说,为佛罗里达海岸今后 50 年,每十年由于融化造成的影响建立模型,要特别注意大型都市区。提出一些适当的回应来处理这些问题。对所使用的数据的详细讨论是答案的一个重要部分。

美国气象数据: <http://www.ncdc.noaa.gov/oa/ncdc.html>

MCM2008 问题 B: 建立数独拼图游戏

建立一个算法,构造一个难度任意变化的数独拼图游戏,通过扩展矩阵大小来定义难度,算

法和矩阵应该是可扩展的,

可以适应任意数目的难度水平。你应该至少设计出 4 个难度水平的算法, 你的算法应该保证结果唯一, 分析你的算法复杂度, 你的目标是用最小的算法复杂度来实现以上的要求。

ICM2008 问题 C: 寻找好的卫生保健系统

国家有一些系统为她们的居民提供卫生保健。通常人们关注的, 而且经常在新闻报道中出现的问题是, 哪个系统更好, 以及是否现有的系统可以得到改善。在不同国家, 这些系统有很多方面是不同的, 例如: 它们是如何提供资助; 是否通过公共, 私人或非营利组织来提供服务; 是否所有居民都享有公共保险; 谁有资格寻求帮助; 都有什么保健项目; 是否最新的医疗措施可供使用, 以及有多少是需要交纳费用的。一些其他因素, 往往在讨论判定医疗服务质量时需要考虑的, 包括: 补充护理的覆盖率 (配镜, 牙科, 假肢, 处方药等); 哪些疾病是影响公共健康的最关键因素; 国内生产总值中用于医疗保健部分所占的百分比; 医疗保健费用中用于劳动/行政/医疗事故保险部分所占的百分比; 公共与私人医疗服务支出的比例, 人均卫生保健支出; 人均卫生保健支出的增长; 参与医师人数; 人均病假天数; 根据年龄, 种族, 性别, 社会经济阶层的良好保健等等。加上与健康相关的其它因素的混合作用, 例如个人锻炼, 粮食供应, 气候, 公民就业和吸烟习惯。世界卫生组织 (WHO), 联合国辖下的机构, 是一个针对卫生因素统计资料的来源。一年一度的世界卫生报告 (<http://www.who.int/whr/en/index.html>) 评估全球健康因素和世界卫生统计报告 (http://en.wikipedia.org/wiki/world_health_organisation) 提供联合国各成员国的卫生统计数据。建立和公布卫生统计报告是 WHO 的一项重要功能。对很多人来说, 这些数据以及相关的分析被认为是针对整个世界的不带偏见的和十分有价值的。还有许多其他来源的可靠的卫生统计数据可用。

第一部分: 描述几个不同的结果 (度量), 可以用来有效评估一个国家的卫生保健体系, 诸如居民的平均预期寿命。什么尺度你会使用来比较现有的和潜在的系统? 你能将多种衡量标准有机的结合起来, 使它们在衡量措施质量的时候更加有用?

第二部分: 筛选当前的数据来源提供的原始数据, 这些数据需要用在计算上面提到的衡量标准上。你可能需要基于这些可用的数据来修改你的度量标准列表。解释为什么你选择这些数据并显示它们如何能够被用来评估和比较存在于不同的国家的相对有效的医疗保健系统。

第三部分: 至少选择三个最重要的、可行的度量来比较卫生保健系统。说明为什么这些是最有用的。可以采取上述的任何一个措施来衡量在现有的卫生保健系统上发生的历史变迁吗? 将它们结合起来可以衡量吗? 数据容易收集吗?

第四部分: 使用你的 3 个 (或更多) 的标准, 来比较美国与另外一个国家的卫生保健系统, 该国家被认为是具有较好的卫生保健系统, 用最近一年内你能找到的数据。哪个国家有更好的卫生保健系统? 你的回答确切吗?

第五部分: 用你的度量, 来比较美国与另外一个国家的卫生保健系统, 该国家被认为是具有较差的卫生保健系统, 用最近一年内你能找到的数据。哪个国家有更好的卫生保健系统?

第六部分: 选一个国家 (美国或其他) 的卫生保健系统, 根据你的衡量方法来改善现有的系统并作出调整。建立预测模型, 以测试种种变化, 以确定是否改变将提高综合质量。提出能够改善现有系统的建议。

MCM2009 问题 A：设计一个交通环岛

在许多城市和社区都建立有交通环岛，既有多条行车道的大型环岛（例如巴黎的凯旋门和曼谷的胜利纪念碑路口），又有一至两条行车道的小型环岛。有些环岛在进出口设有“停车”标志或者让行标志，其目的是给已驶入环岛的车辆提供行车优先权；而在一些环岛的进出口的逆向一侧设立的让行标志是为了向即将驶入环岛的车辆提供行车优先权；还有一些环岛会在入口处设立交通灯（红灯会禁止车辆右转）；也可能会有其他的设计方案。

这一设计的目的在于利用一个模型来决定如何最优地控制环岛内部，周围以及外部的交通流。该设计的目的在于可利用模型做出最佳的方案选择以及分析影响选择的众多因素。解决方案中需要包括一个不超过两页纸，双倍行距打印的技术摘要，它可以指导交通工程师利用你们模型对任何特殊的环岛进行适当的流量控制。该模型可以总结出在何种情况之下运用哪一种交通控制法为最优。当考虑使用红绿灯的时候，给出一个绿灯的时长的控制方法（根据每日具体时间以及其他因素进行协调）。找一些特殊案例，展示你的模型的实用性。

MCM2009 问题 B：能源和手机

这个问题涉及到手机革命的能源问题。手机使用率迅速增加，许多人使用手机并放弃了固定电话。这方面的电能使用会带来什么后果？每个手机都配备了电池和充电器。

要求 1

考虑现在的美国，人口约为 3 亿，从现有数据估计美国有 H 个家庭，每个家庭有 M 个成员，以前是使用固定电话的。现在，假设所有的座机被手机取代，也就是说每个家庭成员都有一部手机。建立当前美国在手机使用的过渡和稳定两个阶段用电改变的模型，分析应该考虑到对移动电话充电的需要，同时移动电话不能像固定电话那样长期使用也是一个现实问题（比如说移动电话可能会丢失或者损坏）

要求 2

考虑“伪美国”--一个约 3 亿人口，跟当前美国具有相同的经济状况的国家。然而，这个新兴国家既没有固定电话也没有移动电话，从能源角度看，为这个国家提供电话服务的最佳方式是什么？当然，手机有很多固定电话所不具有的用途和社会影响。这个讨论要涉及单独使用固定电话或者单独使用移动电话，或者混合使用二者所带来的广泛和潜在的影响。

要求 3

手机需要定期充电。但是许多人在不考虑手机是否要充电的情况下，总是将充电器一直插在电器插槽上，有的甚至整晚都在给手机充电。在你的要求 2 解决方案的基础上，针对“伪美国”，建立上述浪费方式的能源消耗的数学模型。另外，假定“伪美国”以石油作为电力来源，以原油桶为单位计算浪费量。

要求 4

估计各种需要充电的电器设备（电视、DVR、电脑外围设备等）所使用能源的数量，考虑设备没有使用，但插头仍然插在插座上的情况。要求用精确的数据建立模型，估计当前美国每天所浪费的能源数量，以原油（桶/天）计量。

要求 5

考虑人口及经济增长在未来的 50 年内的情况。如何使“伪美国”发展壮大？对于今后 50 年内

的每一个 10 年进行电话服务的能源需求预测，前提是在你前三个要求的分析基础上进行。另外，假定以石油作为电力来源，以原油桶为单位计算。

ICM2009 问题 C：构建食物系统：重新平衡被人类影响的生态系统

背景

仅有不到 1% 的海底被珊瑚覆盖。然而，这里却支持着 25% 的海洋生物多样性。因此，环保主义者非常关心珊瑚的消失，因为随之而来的是这些区域中生物多样性的消失。

考虑位于菲律宾共和国的一个狭窄的通道区域，它位于吕宋岛和 Bolinao 和 Pangasinan 的圣地亚哥岛之间，这里过去长满了珊瑚礁并且支撑了一个巨大的生物种群(如图 1)。在上世纪 90 年代中期，由于商业化虱目鱼(*Chanos chanos*)养殖的引入，这一区域的生物多样性戏剧性地减少。现在海域底部大部分都被淤泥覆盖，曾经这里生活着大量的珊瑚，自从珊瑚被埋葬以后，由于过度的捕捞和缺少野生鱼的栖息地，现在已经很少有野生鱼出没了。然而鱼是当地居民的重要食物来源，寻找新的方法来使得自然生态系统继续繁荣是关系到人民生活的重要事情；也就是要，建立一个混养系统来代替现有的虱目鱼单养系统。最终的目标是要发展一系列水产养殖方法，利用这些方法不但可以经济、科学地支撑当地居民的生活，而且同时可以改善当地的水质，特别是使得珊瑚礁能够重新占据海底，与水产养殖业共存。

理想情况下的混养方案是多种生物混养在一起，一些生物的排泄物恰好是另外一些生物的食物。例如，鲳--鱼的排泄物能被滤食性动物吃掉，鱼和滤食性动物排泄的过度养料能被藻类吸收，这些藻类也可以当做食物或商业副产品销售。这不仅会减少鱼养殖中向周围水体排放的富营养物质，同时也通过利用养鱼产生的大量副产品（贻贝，海带等）来增加农民的收入。就建模的目的而言，生物多样性环境中的主要动物生物体可细分为肉食性鱼类（脊索动物门，亚脊椎亚门）；草食性鱼类（脊索动物门，亚脊椎亚门）；软体动物（如贻贝，牡蛎，蛤，蜗牛等，软体动物门）；甲壳类动物（如蟹，龙虾，藤壶，虾等，节肢动物门，甲壳动物亚门）；棘皮动物（如星鱼，海参，海胆等；棘皮门）和藻类。根据供养种类，有初级生产者（光合作用生产者，如单细胞藻类，浮游植物，藻青菌或多细胞藻类；滤食性动物（株浮游生物，有机颗粒，部分水中微生物）；沉积性动物（吃泥土和消化其中的有机分子和养分）；食草动物（吃初级生产者）；和捕食性动物（如食肉动物）。正如在陆地上，大多数食肉动物吃食草动物或小一些的肉食动物，在海洋中它们也吃滤食性动物和沉积性动物。大多数动物的生长效率只有 10-20%，所以他们摄入的 80-90% 的食物最终会以不同的形式释放出来，有些作为热量散发出来，有些是排泄物。在这一生物多样性的环境中，珊瑚的作用主要是划分空间，并通过让大量生物各自在一个狭小空间内获得适宜生存的环境，来使物种能够集中共存，就像在城市中的高层建筑里一样。珊瑚还可以进行一定的滤食，这有助于水的净化。一个海域支持珊瑚的能力，取决于许多因素，其中最重要的是水质。例如，在 Bolinao，当每毫升海水中含有 50 万至 100 万微生物，以及每升海水中含有 0.25ug 叶绿素（大量浮游植物的替代物）时，珊瑚就能够生存繁殖。目前养殖区的水平是每毫升一千万微生物和每升 15ug 叶绿素。虱目鱼养殖所产生的过剩营养使得海藻快速增长，阻止了珊瑚的生长，由于虱目鱼养殖所产生的颗粒流入，降低了珊瑚进行光合作用的能力。因此，在珊瑚幼虫能够生长之前，必须保持适当的水质。对珊瑚的其他威胁还包括大气中二氧化碳的增加、海洋酸度

上升, 以及全球变暖、海洋温度上升所导致的珊瑚礁退化。这些因素可被视为第二等的威胁, 在本问题中不予考虑。

问题陈述

本问题的任务是设计一个可行的混养系统, 以取代目前单一的虱目鱼养殖, 从而根本改善水质, 让珊瑚幼虫得以在该地区生长。你的混养计划无论在短期还是在长期, 都应是有经济效益并适合环境。

1. 建立进行养殖之前的 Bolinao 珊瑚礁生态系统模型

建立一个完整的珊瑚礁食物链模型, 其中包括作为唯一捕食性鱼类的虱目鱼, 一种草食性鱼类 (由你选择), 一个软体动物物种, 一个甲壳类物种, 一个棘皮动物物种, 和一个藻类物种。确定每个物种你认为合理的数量; 表明你的引用来源或显示你在得出物种数量时进行的估计。阐述你的模型, 说明每个物种如何与其他物种相互作用。说明你的模型如何预测水质的稳定状态, 该水质能够保证珊瑚的持续健康生长。如果你的模型不能得出足够高的水质, 然后调整每一个物种的数量, 直到你取得令人满意的水质水平, 要清楚说明对哪个物种的数量进行了调整, 以及为什么这种调整是合理的。

2. 为目前 Bolinao 单一养殖虱目鱼建模

A 首先, 如果虱目鱼养殖抑制了其他物种, 调查其后果。通过 (设置下列物种种群数量为零) 删除所有食草鱼类, 软体动物, 甲壳动物和棘皮类动物来开展调查。设置所有其他物种种群数量与上述完整模型中的种群数量一致。鉴于你已排除虱目鱼的天然食物供养, 你需使用常数项来模拟渔民喂养箱式虱目鱼; 用该常数项来保持建模平衡。由此, 模型预测什么样水质定态? 水质是否符合珊瑚种类的可持续健康生长? 比较并描述你的结果与观察资料的关系。

B 虱目鱼养殖并未完全抑制其他物种, 同时水质也可能没有 Part 2a 所显示得那么糟糕, 然后通过再次引入所有删除在外的物种并在水质符合博利瑙观测结果时, 利用你的模型来模拟博利瑙现状。比较现有物种种群数量和博利瑙观测到结果, 讨论如何调整模型来才能使你预测的种群数量预测接近所观测到的数量。

3. 对在 Bolinao 混养的修复作用进行建模

现在你需要用一种混养来代替当前的单一养殖, 寻求要让水足够的清澈, 这样你在第一部分中建模的最初的礁生态系统能够不在人类的帮助下重新建立自己。这个想法是想要引入一套相互依靠的物种, 例如, 不管乳香鱼渔民投放什么饲料, 他/她的养殖业的组合都将完全使用, 这样就不会有任何或者只能是最少的废屑料营养物和颗粒物 (饲料和粪便) 沉淀到下面的新生的礁栖息地。并且, 你要从这个多培养物中寻求商业性的收获可食用的生物, 这样才可以给人类提供食品并增加价值。

a. 培养一种商业化的混养来修复 Bolinao 的生态。

从 2b 中的你的“当前的”养殖箱模式, 并且给它引进额外的物种, 这样既可以帮助清洁水质, 又可以产生有价值的、可以收获的生物。例如, 你可以用贻贝, 牡蛎, 蛤蜊或者其它的有经济价值的滤食动物等的养殖箱来进行排列, 这样来去除乳香鱼的一些废物。经济上有价值的水藻在靠近水面 (只要有足够的光线) 的养殖箱的各个侧边上可以生长, 并且有些水藻可以给一些小型的食草鱼提供食物, 而这些食草鱼又可以给乳香鱼提供食物。要求清楚的展示你的模型以及它的稳定状态的数目。

b. 报告你的模型的产量。

你对什么进行了优化? 设置了哪些约束, 为什么要这样设置? 你的模型产生的水质如何? 你的模型能有多大的产量, 经济价值有多少? 进一步提高水质将有多少花费? 换言之, 在最理想的情况下, 每提高一个养殖箱单位的水质, 需要花费多少美元?

4. 科学：讨论供人食用的每一物种的产量。我们怎么使用你的模型来预测和理解供人食用的收获？是不是捕获的食肉鱼数量和收获的海藻数量一样重要所以我们只需要努力最大化收获的重量？还是我们要区分价值（用收获的每一物种的价格来衡量）以至于我们需要努力最大化收获的价值？抑或需要用收获的总价值减去虱目鱼饲料成本来最大化总价值？我们是否要把食用生物价值定义为每种收获物种的总价值减去虱目鱼饲料成本？

5. 最大化总体收获的价值：现在我们希望保持一种在可以接受的（最大化的）水质和获得高价值可出售（因为可以使用和出售的副产品都是可以用来最大化价值的方法）生物之间的平衡关系。在模型中这些可供人类食用生物来源于一切物种。请改变你的模型来从每种物种中获得固定产量。你能获得的生物质（以上定义的）价值以及相对应的水质是多少？请尝试不通收获策略与不同水平的虱目鱼饲养量（总是选择让你的模型保持平衡的价值），同时牢记把水质作为一个收获价值功能。哪个策略是最佳的，什么是最佳的收货？

6. 要求采取行动

给太平洋海洋渔业委员会的主席写一篇资料论文，要综述你在生物多样性和用于珊瑚生长的水质之间关系的发现。包括用于像 Bolinao 地区的修复战略，以及实施的时限。展示你在第五部分中的最优化收获/饲养战略，以及具有说服力的证明，并且说明建议的渔业/收获指标来支持你的计划。通过展示你的计划中的收获价值的比例与当前的 Bolinao 地区的收获价值的比例来表明你的战略的杠杆作用。从生态角度来讨论实施你的混养系统的赞成和反对的理由。

补充信息：

图一：图中所示 Bolinao 区域和在水质分析（表格 1 和 2）取样地点。图中地点 A 和 B 的珊瑚礁完全健康。然而地点 C 的珊瑚礁已经退化。此时地点 D 仍有少量珊瑚礁存活，但绝大部分的珊瑚礁和藻类已经死亡。而且在该区域的鱼类笔下方根本没有活的珊瑚。在鱼类笔投放的海峡，渔民使用的鱼箱体积大致为 10M*10M*8M，每个鱼箱的鱼密度为~50000 条，每公顷 10 个鱼箱。

以下表格中的数据容易搜到。从你自身目的出发这些数据可能不够。这些数据只是为了提供一些让你如何开展的样例提示。你应该使用你自己能找到的最适合和完整的数据。

地点取样水质特征：

表格 1

地点	溶解的有机碳 (DOC) (uM)	总氮 (溶解的, uM)	叶绿素 (ug/L)	颗粒有机碳 (POC) (ug/L)	总氮 (颗粒, ug/L)
鱼类笔					

不同水域微生物丰度和微粒特性

表 2 Bolinao 水域菌类和微粒丰度

水域	类似病毒的微粒丰度 (#/毫升)	非寄生菌丰度(细胞/毫升)	寄生菌丰度 (细胞/毫升)	寄生菌占总数的百分比	每毫升微粒的数量(微粒尺寸大于 3 微米)		微粒平均大小 (微米)
					腐质	浮游植物细胞数	

							米 ²)
A	1.0±0.07 x 107	5.4±0.3 x 105	5.3±2.2 x 102	<0.1	3.4±0.2 x 103	2	42.7
B	0.8±0.04 x 107	4.2±0.6 x 105	3.9±0.6 x 102	<0.1	4.4±0.2 x 103	2	19.7
C	1.7±0.1 x 107	3.0±0.04 x 105	113.7±3.6 x 102	3.7	9.6±0.8 x 103	2	65.8
D	7.0±0.3 x 107	6.1±0.6 x 105	144.5±5.6 x 102	2.3	14.4±0.1 x 103	2	576.1
养 鱼 箱	6.1±0.7 x 107	9.9±0.3 x 105	583.2±28.1 x 102	5.6	11.3±0.5 x 103	2 78.4±5.5 x 10	280.8

生物体信息

生物体	营养类型	进食对象	进食量	排泄物	捕捞价值
遮目鱼 (data from Homer et al. 2002)	肉食类	鱼饲料或小鱼	在养鱼箱内: 6.58kg/m ² 的养鱼箱/ 5 月	242–493 g 干重的沉渣 / m ² /天. 沉渣的 10%是碳, 0.4%是氮, 以及 0.6% 磷 (百分比指的是干重)	1, 278 美元/公吨(from Agribusiness Weekly)
食草鱼 (<i>Siganus doliatus</i> , a rabbit fish, used as representative)	草食类	大型藻类 (肉质藻)	~18–22 cm ³ 的藻类物质/ m ² 的珊瑚礁/ 月 (from Fox & Bellwood 2008)		
甲壳类动物和片足动物 (data averaged over one crab (<i>Menaethius monoceros</i>) and one amphipod (<i>Cymadusa imbroglia</i>) from Cruz-Rivera & Paul 2006)	草食类	大型藻和蓝藻	~10–20mg 湿重食物/个体 /天		各种可食甲壳类动物的价值可以通过公众来证实。

软体动物 (Averaged over 5 species of mussels and oysters from Hawkins et al. 1998)	滤食类	直径 1–16um 的微生物	他们过滤 5-7L 水/小时的微粒并吸收 4–15mg 有机物/克无水软组织(动物尺寸标准)/小时		各个物种的捕捞价值在网络上也可以找到
棘皮动物 (urchin, <i>Tripneustes gratilla</i> , from the Philippines as representative. Data from Dy et al. 2002)	草食类	肉质藻	~0.05 g 湿重藻类/g 干重海胆/ 小时 每个海胆的平均重量是 6.9 g	0.2–11.5mg 干重粪便 /g 干重海胆	
海藻 (Yokoya and Oliveira 1992)	初级食物生产者	阳光, 二氧化碳, 氮和磷	依据温度, 经济上很重要的红藻可以在最短 2.8 天(<i>Hypnea cornuta</i>) 最长 50 天 (<i>Pterocladia capillacea</i>) 的时间内将其重量(湿重) 翻番	这些有机体能够以可溶有机碳的形式排出多余的光合作用产物, 但很难计算其数量。只要记住这个过程在你思考第六部分的生态前景时会出现就可以了。	

MCM2010 Problem A: The Sweet Spot

Explain the “sweet spot” on a baseball bat.

Every hitter knows that there is a spot on the fat part of a baseball bat where maximum power is transferred to the ball when hit. Why isn’t this spot at the end of the bat? A simple explanation based on torque might seem to identify the end of the bat as the sweet spot, but this is known to be empirically incorrect. Develop a model that helps explain this empirical finding.

Some players believe that “corking” a bat (hollowing out a cylinder in the head of the bat and filling it with cork or rubber, then replacing a wood cap) enhances the

“sweet spot” effect. Augment your model to confirm or deny this effect. Does this explain why Major League Baseball prohibits “corking”?

Does the material out of which the bat is constructed matter? That is, does this model predict different behavior for wood (usually ash) or metal (usually aluminum) bats? Is this why Major League Baseball prohibits metal bats?

MCM2010 问题-A：最佳击球点

解释棒球棒上的“SweetSpot”。

每个打击手都知道在棒球棒的厚端有一个点，当用它击球时能够传递出最大的力量。为什么这一点不在球棒的一端？一个基于扭矩的简单解释看上去能够确认球棒一端是最佳击球点，但这是众所周知的与实际经验不符。建立一个模型帮助解释这个实际经验。

有些选手认为“塞住”球棒（在球棒一头挖出一个圆柱空腔，并用软木塞或者橡胶填满，这样更换了木质棒顶）能够增强“最佳击球点”效应。补充你的模型来确认或者否定这个效果。这是否解释了为什么职业棒球联盟都禁止“塞住球棒”？

球棒的制作材料是否会有影响？也就是说，你的模型是否对木质（通常是木屑）或者金属（通常是铝）球棒的表现作出不同的预测？这是否是职业棒球联盟都禁止金属球棒的原因？

MCM2010 Problem B: Criminology

In 1981 Peter Sutcliffe was convicted of thirteen murders and subjecting a number of other people to vicious attacks. One of the methods used to narrow the search for Mr. Sutcliffe was to find a “center of mass” of the locations of the attacks. In the end, the suspect happened to live in the same town predicted by this technique. Since that time, a number of more sophisticated techniques have been developed to determine the “geographical profile” of a suspected serial criminal based on the locations of the crimes.

Your team has been asked by a local police agency to develop a method to aid in their investigations of serial criminals. The approach that you develop should make use of at least two different schemes to generate a geographical profile. You should develop a technique to combine the results of the different schemes and generate a useful prediction for law enforcement officers. The prediction should provide some kind of estimate or guidance about possible locations of the next crime based on the time and locations of the past crime scenes. If you make use of any other evidence in your estimate, you must provide specific details about how you incorporate the extra information. Your method should also provide some kind of estimate about how reliable the estimate will be in a given situation, including appropriate warnings.

In addition to the required one-page summary, your report should include an additional two-page executive summary. The executive summary should provide a broad overview of the potential issues. It should provide an overview of your approach and describe situations when it is an appropriate tool and situations in which

it is not an appropriate tool. The executive summary will be read by a chief of police and should include technical details

MCM2010 问题-B：犯罪学

在 1981 年 Peter Sutcliffe 因为 13 次连环谋杀和一系列的恶意伤害被判有罪。在该案中的一种用来缩小搜索罪犯所在范围的方法是找到这些犯罪地点发生的“重心”。而在最后结案时罪犯恰好生活在用这种技术所预测的那个城镇里。从那时开始，更多更复杂的技术被发展起来通过系列犯罪的地点用来确认罪犯的“地理轮廓”。

你们的团队要帮助一个地方警署发展一种辅助他们调查连环犯罪的方法。你们创造的这种方法应该用至少两种不同方式去生成“地理轮廓 (geographical profile)” 。你们要用一种方法综合这些不同方法的结果去产生一个对警察有用的预测。你们的预测还应该提供基于之前犯罪发生的时间和地点而生成的对下次犯罪可能的时间和地点的预测。如果你们使用了除时间和地点之外的证据于你们的模型中，你们还必须说明你们将这些证据整合于模型的具体细节方式。你们同意说明你们的预测在实际中的可依赖度，包括合适的警告 (appropriate warnings)。除了要求的一页摘要以外，你的报告应该包括一个额外的 2 页纸的实施概要。这个概要应该对潜在问题进行综述。它要概述你的方法,描述你的方法适合以及不适合的情况。概要将会被呈给**局长阅读，所以概要中应包括适当的技术细节以适合其读者。

ICM2010 问题-C：海洋垃圾积累所带来的复杂的问题

今年来，对于太平洋巨大垃圾漂浮带有着广泛的报道。参见如下网站：

根据近年来科学家对太平洋垃圾回旋区（也就是海洋上垃圾的不断积累的汇集区）的研究，出现了与此垃圾带相关的多种的技术的和科学的问题。然而向海洋中倾倒垃圾不是一个新问题，但是科学家最近才发现，在太平洋上的大部分垃圾（尤其是塑料）分布越来越广，密度越来越高，而且垃圾对海洋生态和人类和人类的福祉造成了潜在的威胁。业内人士经常把这种积累描述为塑料汤(plastic soup)或者 confetti. 参见：

今年的 icm 问题时一个跨学科的建模，用来研究当前海洋垃圾积累所带来的复杂的问题，目的是帮助研究者以及最终的政府政策的制定者来理解问题的严重性、范围和潜在的全球性影响。

作为数学模型的设计者，你的任务是关注垃圾问题的一个方面，建立模型并分析他的行为，并且决定他对海洋生态、政府政策以及实施的潜在影响，以帮助政府政策的制定者来改善它的负面影响。务必要考虑未来科学研究的需要以及这个问题的经济因素，然后写一篇报告，对你的发现和问题的建议、需要的政策以及实施方法进行总结。建模中可能需要调查的问题包括：

1. 对于海洋环境中塑料物的潜在的长期和短期的影响是什么？怎样来监控他对海洋生态环境的影响？务必要考虑到时间和空间的变量。相关的资源要求是什么？
2. 如何才能最好的理解和描述垃圾回旋区中的塑料的广度(extent)、密度和分布？需要什么样的监控计划来追踪塑料的增长/腐烂/运动,需要什么样的资源(resourcing)来执行这个计划？

3. 当他进入海洋并且在回旋带汇集, 塑料光降解的性质和机制是什么, 其构成是什么? (例如我们很惊奇的发现降解后的塑料的粒子一般会达到类似的大小)。
 4. 这些塑料来自于什么地方? 对于这种情况应该采取什么措施来控制和减少这种情况所带来的风险? 控制和终止这种情况, 会有什么样的经济成本和收益? 二者之间的比较效益是什么? 塑料的生产量是多少? 抛弃的有多少? 回收再利用的有多少? 可能进入海洋的有多少? 有可能漂浮的有多少?
 5. 类似的情况会在海洋的其它地方出现吗? 我们应该监控什么? 如何监控? 在北大西洋回旋区和阿拉斯加回旋区又会发生什么? 用你的模型来对评估一下未来在南大洋 (南大西洋和南太平洋) 的塑料的密度。
 6. 如果禁止使用聚苯乙烯包装盒, 会有什么样的直接影响? 参见。。。在未来 10 到 50 年的影响是什么?
 7. 建模中也可以涉及到其它的科学和技术问题, 只要此模型是你的调查和研究中的重要组成部分。
- 为了使你的表述更加清晰, 请关注此问题的一个重要方面, 并对一些重要现象中的行为进行建模。确定其中最具当下和长远意义的部分进行建模和分析。你的 icm 报告应该是一份 10 页的团队报告。

MCM2011 Problem A: Snowboard Course

Determine the shape of a snowboard course (currently known as a “halfpipe”) to maximize the production of “vertical air” by a skilled snowboarder.

“Vertical air” is the maximum vertical distance above the edge of the halfpipe.

Tailor the shape to optimize other possible requirements, such as maximum twist in the air.

What tradeoffs may be required to develop a “practical” course?

MCM2011 问题-A：滑雪场问题

确定一个滑雪场 (现在仅知是半管状) 的形状来使得一个滑板运动员所能达到的垂直间距最大化。垂直间距是指, 距半管状的边缘间的最大垂直距离。修改形状以适应其他要求, 例如使得运动员的扭转最大化。要建造一个实用的场地, 又该做出何种取舍?

MCM2011 Problem B: Repeater Coordination

The VHF radio spectrum involves line-of-sight transmission and reception. This limitation can be overcome by “repeaters,” which pick up weak signals, amplify them, and retransmit them on a different frequency. Thus, using a repeater, low-power users

(such as mobile stations) can communicate with one another in situations where direct user-to-user contact would not be possible. However, repeaters can interfere with one another unless they are far enough apart or transmit on sufficiently separated frequencies.

In addition to geographical separation, the “continuous tone-coded squelch system” (CTCSS), sometimes nicknamed “private line” (PL), technology can be used to mitigate interference problems. This system associates to each repeater a separate subaudible tone that is transmitted by all users who wish to communicate through that repeater. The repeater responds only to received signals with its specific PL tone. With this system, two nearby repeaters can share the same frequency pair (for receive and transmit); so more repeaters (and hence more users) can be accommodated in a particular area.

For a circular flat area of radius 40 miles radius, determine the minimum number of repeaters necessary to accommodate 1,000 simultaneous users. Assume that the spectrum available is 145 to 148 MHz, the transmitter frequency in a repeater is either 600 kHz above or 600 kHz below the receiver frequency, and there are 54 different PL tones available.

How does your solution change if there are 10,000 users?

Discuss the case where there might be defects in line-of-sight propagation caused by mountainous areas.

MCM2011 问题-B：中继站的协调

甚高频无线电频谱包含信号的发送和接受。这种限制可以被中继站所克服。中继站可以捕捉到微弱的信号，然后把它放大，再用不同的频率重新发送。这样，低功耗的用户，例如移动电话用户，在不能直接与其他用户联系的地方可以通过中继站来保持联系。然而，中继站之间会互相影响，除非彼此之间有足够远的距离或通过充分分离的频率来传送。

除了地理的分离、“连续编码音调控制系统”(CTCSS),有时被称为“私人专线”(PL)、通过这项技术可以减轻干扰问题。该系统连接每个中继站，靠的是所有通过同一个中继站连接的用户发送的独立的亚音频音调来连接。中继站只回应接收到的具有特殊 PL 的语调的信号。通过这个系统,两个附近的中继站可以共享相同的频率对(包括接收和发送);对于更多的中继站(并且更多的用户)可以提供在一个特定的区域。在一个半径 40 英里的圆形区域，请你设计一个方案，用最少量的中继站来容纳 1000 同时在线用户。假设频谱范围是 145 到 148 兆赫,在中继站中的发射机的频率要么是 600 千赫以上，要么低于接收机频率 600 千赫、并且这里有 54 个不同的 PL 可用。

如果这里有 10,000 个用户，如何改变你的解决方案。

在由于山区引起信号传播的阻碍的地区，讨论这样的情形。

ICM2011 问题-C：电动汽车

从环保和经济上说，电动汽车究竟有多少优势？它们的普及是可行和实用的吗？

这里有一些问题需要考虑，但是，当然还有更多问题，你将无法在模型中考虑所有的问题：

电动汽车的广泛使用会节约化石燃料吗？或者实际上仅仅是给了化石燃料另一个交易使用的方式，电力目前主要是燃烧化石燃料产生的。要想通过使用电动汽车来最多地节约能源，需要什么条件到位才可以？

在二十一世纪要想广泛使用可行和有利于环境的电动汽车，需要多少的电力的替代品，如风力和太阳能。评估是否这些替代电力来源的增长是可能和可行的。

在非高峰时间给电池充电是否是有益的？能增加广泛使用电动汽车的可行性吗？电池需要以多快的速度充电才能最大限度地提高电动车的效率和的实用性？在环境节约和广泛使用电动车辆的可行性方面，这些地区还需要做多大规模的改进？

• 什么样的基础交通工具的方法是最有效的？不同方法的有效性是基于使用它的国家或地区的情况吗？

直接由电动汽车造成的污染是很低的，但是与电动汽车相联系的有隐性污染源吗？汽油和柴油在引擎内部燃烧产生含亚硝酸盐的氧气，车辆产生一氧化碳和二氧化碳污染，但这些双向产品是我们真正应该担心的吗？在气候和我们的健康方面，什么是这些物质的短期和长期的影响？

• 日益增加的需要处理的大容量电池所造成的污染究竟有多大？比较一下电动汽车对于环境的影响和化石燃料燃烧的车辆的影响。

• 你还应该考虑诸如经济和人口问题，诸如电动车辆的便利性。电池可以足够快速地充电或更换吗？以便能满足大多数运输的需要或者它们的使用范围受到限制吗？在交通运输中，电动汽车只有有限的作用吗？只对于短途运输（短途客运或轻型车辆）有作用吗？或他们实际上可以用于高负荷、长途的交通运输？政府应当给予补贴来发展电动车技术吗？如果需要，为什么？需要补贴多少，以何种形式？

要求

• 建立电动汽车广泛使用对于环境，社会，经济和健康影响的模型，并且详细阐述政府和电动汽车生产商是否应该支持电动汽车的广泛使用，如果支持的话，应该考虑的关键点。并且提供验证你的模型需要的数据

• 应用你的模型预测广泛使用电动汽车下世界范围内要节省多少石油（化石燃料）

• 提供一个与你所建立的电动汽车数量和形式的模型相匹配的发电站的数量和形式的模型，该模型要 对环境、社会、商业和个人产生最大的收益。

• 写一个 20 页的报告(不包括摘要页)，提出你的模型和你对于电动汽车和发电站关键问题的分析。一定要包括政府在确保安全、高效、有效的交通上所扮演的角色。讨论引进广泛使用电动汽车是否是值得的，并且在面对化石燃料供应短缺下，是否是满足全球能源需求的总体战略的重要组成部分。

2012 MCM Problems

MCM2012 Problem A: The Leaves of a Tree

"How much do the leaves on a tree weigh?" How might one estimate the actual weight of the leaves (or for that matter any other parts of the tree)? How might one classify leaves? Build a mathematical model to describe and classify leaves. Consider and answer the following:

- Why do leaves have the various shapes that they have?
- Do the shapes "minimize" overlapping individual shadows that are cast, so as to maximize exposure? Does the distribution of leaves within the "volume" of the tree and its branches effect the shape?
- Speaking of profiles, is leaf shape (general characteristics) related to tree profile/branching structure?
- How would you estimate the leaf mass of a tree? Is there a correlation between the leaf mass and the size characteristics of the tree (height, mass, volume defined by the profile)?

In addition to your one page summary sheet prepare a one page letter to an editor of a scientific journal outlining your key findings.

MCM 2012 A-题：树的叶子

“一棵树的叶子有多重？”怎么能估计树的叶子（或者树的任何其它部分）的实际重量？怎样对叶子进行分类？建立一个数学模型来对叶子进行描述和分类。模型要考虑和回答下面的问题：

为什么叶子具有各种形状？

叶子之间是要将相互重叠的部分最小化，以便可以最大限度的接触到阳光吗？树叶的分布以及树干和枝杈的体积影响叶子的形状吗？

就轮廓来讲，叶形（一般特征）是和树的轮廓以及分枝结构有关吗？

你将如何估计一棵树的叶子质量？叶子的质量和树的尺寸特征（包括和外形轮廓有关的高度、质量、体积）有联系吗？

除了你的一页摘要以外，给科学杂志的编辑写一封信，阐述你的主要发现。

MCM 2012 Problem B: Camping along the Big Long River

Visitors to the Big Long River (225 miles) can enjoy scenic views and exciting white water rapids. The river is inaccessible to hikers, so the only way to enjoy it is to take a river trip that requires several days of camping. River trips all start at First Launch and exit the river at Final Exit, 225 miles downstream. Passengers take either oar- powered rubber rafts, which travel on average 4 mph or motorized boats, which travel on average 8 mph. The trips range from 6 to 18 nights of camping on the river, start to finish.. The government agency responsible for managing this river wants every trip to enjoy a wilderness experience, with minimal contact with other groups of

boats on the river. Currently, X trips travel down the Big Long River each year during a six month period (the rest of the year it is too cold for river trips). There are Y camp sites on the Big Long River, distributed fairly uniformly throughout the river corridor. Given the rise in popularity of river rafting, the park managers have been asked to allow more trips to travel down the river. They want to determine how they might schedule an optimal mix of trips, of varying duration (measured in nights on the river) and propulsion (motor or oar) that will utilize the campsites in the best way possible. In other words, how many more boat trips could be added to the Big Long River's rafting season? The river managers have hired you to advise them on ways in which to develop the best schedule and on ways in which to determine the carrying capacity of the river, remembering that no two sets of campers can occupy the same site at the same time. In addition to your one page summary sheet, prepare a one page memo to the managers of the river describing your key findings.

MCM 2012 问题-B: 大长河沿岸露营

大长河 (225 英里) 可以欣赏风景的意见和令人兴奋的白色水激流。这条河无法通过远足活动访问, 所以享受它的唯一方法就是去河旅行, 需要几天的露营。河 trips 一切开始在第一次启动和退出在最终退出, 河下游 225 英里。乘客拿桨-动力橡胶木筏, 平均旅行 4 英里每小时, 或机动的船, 平均旅行 8 英里每小时。Trips 的范围是从 6 到 18 夜的露营在河上的开始完成...负责管理这条河的政府机构希望每次去享受荒野的经验, 与其他团体的船在河上最少接触。目前, X trips 旅行下大长条河每年在六个月期间 (今年太冷河旅行的其余部分)。大长江, 相当均匀分布于整个河流廊道上有 Y 营地。鉴于河漂流的兴起, 公园经理被要求允许更多的旅行, 沿着这条河。他们想要确定如何, 他们可能会安排班次, 不同的持续时间 (以夜河上衡量) 的最优组合和推进 (电机或桨) 将利用露营可能的最佳方式。换句话说, 多少更多船旅行能被添加到大长河漂流季节? 河经理雇你, 向他们提供关于各种方法, 制定最佳计划和各种方法, 确定承载力的河, 记住没有两个集的露营者可以占用相同的站点, 在同一时间。除了您一页摘要表外, 还准备管理者的描述您的主要调查结果的河的一页备忘录。

ICM 2012 问题-C 题: 犯罪克星

你的组织, 银河犯罪建模中心 (ICM), 正在调查一个实施犯罪行为的阴谋。调查人员现在非常有信心, 他们已经知道策划阴谋的一些成员, 但是他们希望在逮捕嫌疑人之前确定其它的犯罪成员和组织的领导人。所有的嫌疑人和可能涉嫌的同谋都受雇于同一家公司, 在一个大的综合办公室里工作。该公司发展迅速, 正在开发和销售以自己的名字命名的计算机软件, 该软件是为银行和信用卡公司服务的。ICM 最近从公司的一组员工 (有 82 人) 那里获得了一些消息, 他们认为这将帮助他们找到最有可能的未知身份的同谋者和组织领导人。由于公司中的所有员工都知晓该消息, 所以一些消息的传播者 (有可能很多) 并没有卷入阴谋。

事实上，他们可以确定有一些人没有卷入阴谋。建模工作的目标是确定在综合办公室里的人谁最有可能是同谋者。一个优先级列表是最理想的，ICM 可以按照优先级调查、监视或者审问最有可能的嫌疑人。一个判别是否为同谋人的分界线也是非常有用，可以用它来对各组人进行分类。对于检方来讲，如果模型能够识别出阴谋策划的领导人也是非常有帮助的。在你的犯罪建模团队获得当前案件的数据之前，你的上司给了你们下面的一些场景（被称作调查 EZ），这些场景是几年前她在其他城市工作时遇到的。尽管她对她在 EZ 案件上的工作非常自豪，她仍然谦虚地说那是一个小的、简单的案例，但它可以帮助你了解你的任务。她的数据如下：

她考虑为同谋者的十个人分别为：Anne#， Bob， Carol， Dave*， Ellen， Fred， George*， Harry， Inez， and Jaye#。（*号表示事先已知是同谋者，#号表示事先已知为非同谋者）

下面是 28 条消息的列表，这些消息是在她的案件中获得的，每条消息后面有一个标号，这个标号反映了她对于消息的主题的分析。

安妮对鲍勃说：为什么你今天迟到了？（1）

鲍勃对卡罗尔说：这该死的安妮总是看着我。我没有迟到。（1）

卡罗尔对戴夫说：对于鲍勃的迟到，安妮和鲍勃有争执。（1）

戴夫对艾伦说：我需要今天早晨看见你。什么时候你能来？把预算文件带来。（2）

戴夫对弗雷德说：今天我随时都可以来见你。如果时间合适就告诉我。我应该把预算文件带上吗？（2）

戴夫对乔治说：我之后要见你---有很多话要说。我希望其他人做好准备。重要的是要得到这个权利。（3）

哈里对乔治说：你似乎在强调。这是怎么回事？我们的预算很优秀。（2）（4）

伊内兹对乔治说：我今天真的感觉很累。你感觉怎么样？（5）

杰伊对伊内兹说：今天没有太多事可做。去吃午餐怎么样？（5）

伊内兹对杰伊说：好想法，但是我筋疲力尽了，不能做午餐了，对不起！（5）

乔治对戴夫说：谈话时间，现在！（3）

杰伊对安妮说：你今天能去吃午餐吗？（5）

戴夫对乔治说：我不能。我要在回家的路上去看弗雷德。（3）

乔治对戴夫说：那之后到这。（3）

安妮对卡罗尔说：谁应该去看看鲍勃？他正在消磨时间。（1）

卡罗尔对安妮说：别理他。他和乔治、戴夫相处的很好。（1）

乔治对戴夫说：这是非常重要的。该死的弗雷德。艾伦如何？（3）

艾伦对乔治说：你和戴夫谈话了？（3）

乔治对艾伦说：还没有。你呢？（3）

鲍勃对安妮说：我没有迟到。我要让你知道---午餐时间我也在工作。（1）

鲍勃对戴夫说：告诉他们我没有迟。你知道的。（1）

艾伦对卡罗尔说：去找安妮，弄清楚下周预算会议的具体日程，并且帮助我让乔治冷静一下。（2）

哈里对戴夫说：你没有注意到今天乔治又压力很大？（4）

戴夫对乔治说：该死的哈里认为你压力很大。不要让他担心或者别让他察觉。（4）

乔治对哈里说：仅仅是因为工作太晚了，家里也出了点问题。我很好。（4）

艾伦对哈里说：如果我错过了今天的会议，一切还会都好吗？弗雷德在会议上，他知道的预算比我做的好。（2）

哈里对弗雷德说：我认为明年的财政预算案使一些人压力很大。也许我们应该花些时间来让人们放心。（2）（4）

弗雷德对哈里说：我认为我们的预算是非常健康的。我没有看到任何压力。（2）

消息流完毕。

你的上司指出，她分配并编码了仅仅 5 种不同的消息主题：1) 鲍勃的迟到，2) 预算，3) 重要但未知的问题，被认为是阴谋的一部分，4) 乔治的压力，5) 午餐和其他社会问题。正如所看到的消息编码，一些消息因为其内容被和两个主题联系在了一起。

你的上司分析情况采用的方法是一个网络，它显示了消息的通讯连接情况和消息的类型。下图是一个消息网络模型，网络图上注明了消息类型的代码。

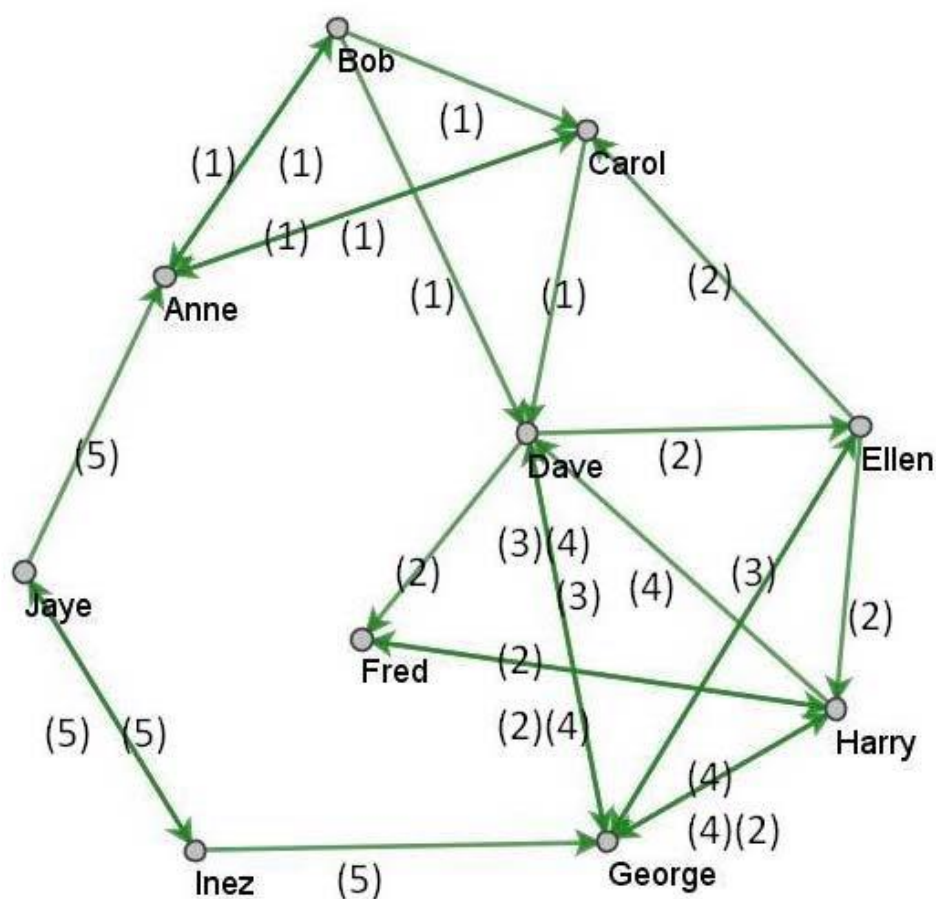


图 1: EZ 案件的消息网络

你的上司指出，除了已知的同谋乔治和戴夫，根据她的分析，艾伦和卡罗尔分别被因为同谋起诉，后来鲍勃自己认罪，被判处减刑。但对卡罗尔的起诉后来被撤销了。你的上司仍然坚信伊内兹参与其中，但对于她的诉讼始终没能成立。你的上司给你们团队建议，一定要明确人群中有一小部分人，像伊内兹这样的

人不能漏网，像卡罗尔这样的人也不能被错误地起诉，并且 ICM 得到证据，像鲍勃这样的人就没有机会获得减刑。

目前情况下，你的上司已经得到了一个网络形式的数据库，它有着相同的结构，但是在规模上稍大一些。有一些迹象表明，一个阴谋正在从公司挪用资金，并且使用网络欺诈窃取与公司做生意的的人的信用卡内的资金。她给你示范了一个小例子，在 EZ 情况下只有 10 个人（节点），27 条边（信息），5 个主题，一个可疑的/阴谋的主题，2 个已知的同谋者，还有 2 个已知的非同谋者。

目前，这个新的情况下，有 83 个节点，400 条边（其中一些包含不止一个主题），超过 21000 个字符的信息传输，15 个主题（3 个被视为是可疑的），7 个是已知的同谋者，还有 8 个已知的非同谋者，数据在给出的附件：Names.xls, Topics.xls, Messages.xls 和 Names.xls 中，names.xls 包含办公室员工的姓名，和节点的数目一样。topics.xls 包含了 15 个主题的代码和简短描述。由于安全和隐私的问题，你的团队将不能得到所有信息流的副本。messages.xls 提供链接节点的，用来传递信息的边，信息中包含数字代码。一些信息包含了三个主题。为了可视化信息流动，对于人和信息传播的网络模型如图 2 所示。图上没有像图 1 一样标注消息的主题。这些主题的编号在文件 Messages.xls 中给出，主题描述在 Topics.xls 中给出。

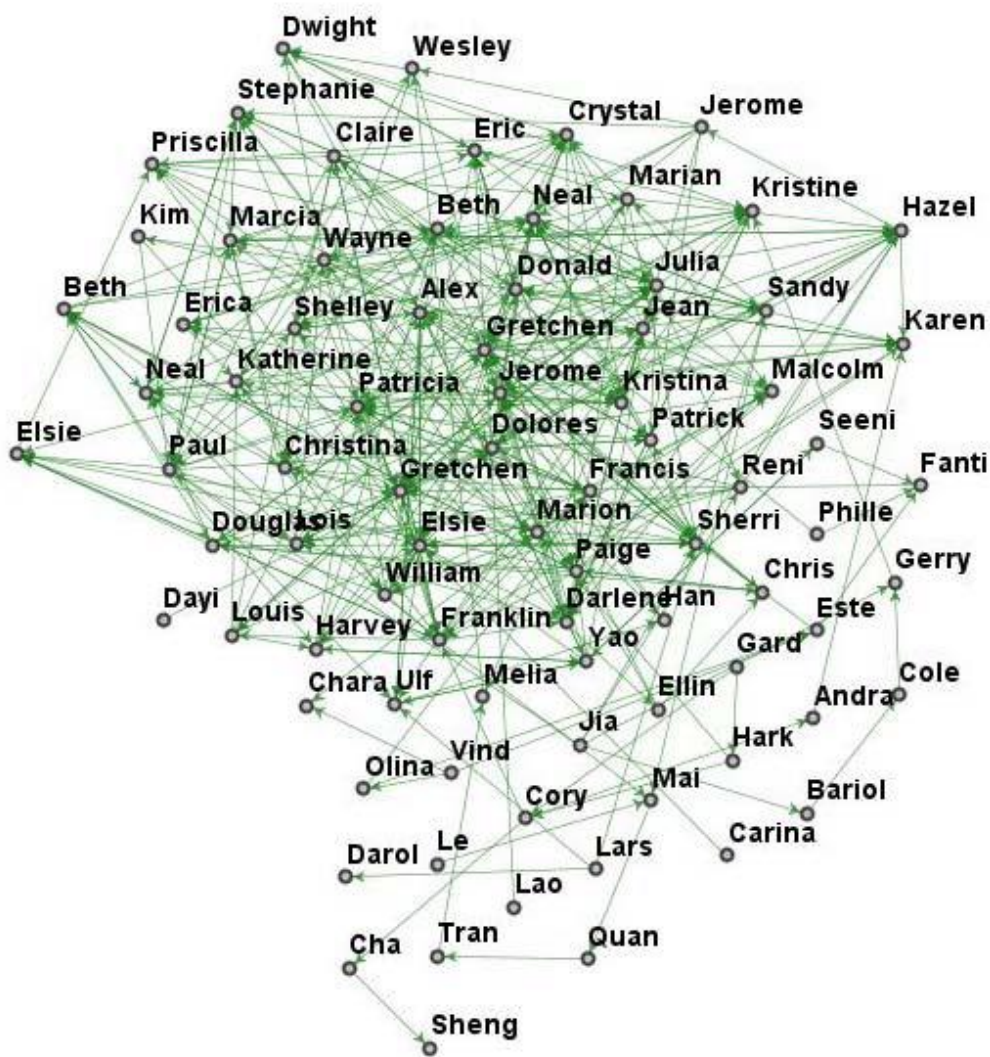


图 2: 可视化的网络模型, 包含 83 个人 (节点) 和 400 条他们之间的信息 (边)
要求:

要求一:

目前, 已知 Jean, Alex, Elsie, Paul, Ulf, Yao, 和 Harvey 是同谋者, 还知道 Darlene, Tran, Jia, Ellin, Gard, Chris, Paige, 和 Este 不是同谋者。3 个已知的可疑信息主题为 7, 11 和 13。更多的主题细节请见附件 Topics.xls。根据 83 个节点为阴谋的可能性的, 建立一个模型和算法对可能性大小进行排序, 并说明你的模型及流程。Jerome, Delores 和 Gretchen 是公司的高级管理人员, 如果能知道他们中的任何一个是否参与了这个阴谋将是十分有用的。

要求二:

如果得到新的消息, 主题一和阴谋有关, 且 Chris 是同谋者之一, 请问要求一中的排序会是什么样子的?

要求三:

和这个消息传输类似的一种强大的用来获得和理解文本信息的技术被称为语义网消息传输分析。作为一个在人工智能和计算语言学的方法, 它为知识推理和语言提供了一个结构和过程。另一种在自然语言处理能力方面的计算语言学叫做文本分析。在我们的犯罪现场破坏条件下, 解释语义和文本内容的分析和消息传输的背景(如果你能获得原始信息)能使您的团队开发更好的关于办公室人员的模型和归类。你是否在文件 Topics.xls 中有使用这些功能来进行主题描述, 从而提升你的模型?

要求四:

你完成的报告最终将送给检察官, 所以报告中必须详细的, 清晰的陈述你的假设和方法论。但是报告不能超过 20 页。你可以在分开的文件中包含你的程序作为附录, 附录不算在你的页数内, 但这些附录不是必要的。你的上司希望 ICM 在解决白领, 高技术的阴谋犯罪方面是世界上最好的。希望你提供的方法将有助于解决世界各地重大案件, 尤其是那些拥有非常大消息传输的数据库(成千上万的人, 成千上万的信息, 可能数百万字)。她特别要求你在报告中要包含可以帮助你的信息模型和建议的讨论如何更深入的网络、语义和文本内容的分析的内容。作为你向她报告的一部分, 说明你使用的网络建模技术, 和你为什么使用它以及如何使用它在任何类型的网络数据库用来识别, 优先和分类相似节点, 而不仅仅是犯罪阴谋和信息数据。

例如, 在得到节点感染概率和部分已经确认感染节点的各种图像或化学数据的生物网络中, 你的方法能否找到感染或患病的细胞的位置?

*你提交的 ICM 论文应该包含一页摘要和不超过 20 页的解决方案, 总计不超过 21 页。

MCM2013 Problem A The Ultimate Brownie Pan

When baking in a rectangular pan heat is concentrated in the 4 corners and the

product gets overcooked at the corners (and to a lesser extent at the edges). In a round pan the heat is distributed evenly over the entire outer edge and the product is not overcooked at the edges. However, since most ovens are rectangular in shape using round pans is not efficient with respect to using the space in an oven. Develop a model to show the distribution of heat across the outer edge of a pan for pans of different shapes - rectangular to circular and other shapes in between.

Assume

1. A width to length ratio of W/L for the oven which is rectangular in shape.
2. Each pan must have an area of A .
3. Initially two racks in the oven, evenly spaced.

Develop a model that can be used to select the best type of pan (shape) under the following conditions:

1. Maximize number of pans that can fit in the oven (N)
2. Maximize even distribution of heat (H) for the pan
3. Optimize a combination of conditions (1) and (2) where weights p and $(1-p)$ are assigned to illustrate how the results vary with different values of W/L and p .

In addition to your MCM formatted solution, prepare a one to two page advertising sheet for the new Brownie Gourmet Magazine highlighting your design and results.

MCM 2013 问题-A: 最佳巧克力蛋糕烤盘

当你使用一个矩形的烤盘烘烤食物时, 热量会集中在烤盘的四个角落, 于是角落处的食物就会被烤糊(烤盘边缘处也有类似情形, 但程度轻一些)。当使用一个圆形烤盘时, 热量会均匀地分布在整個边缘上, 就不会再有边缘上烤糊的现象发生。然而, 由于大多数烤箱内部是矩形的, 如果使用圆形烤盘, 就不能充分利用烤箱的内部空间了。

建立一个模型, 来描述热量在不同形状的烤盘表面的分布。这些形状包括矩形、圆形以及两者之间的过渡形状。

假设, 1、矩形烤箱的宽长比为 W/L 。2、每个烤盘的面积为 A 。3、先考虑烤箱内有两个搁架且间隔均匀的情形。

建立一个模型用以选择满足下列条件的最佳烤盘的形状: (1)、使得烤箱中可以容纳的烤盘数量(N)最大。(2)、使得烤盘上的热量分布(H)最均匀。3、综合(1)、(2)两个条件, 并且为(1)、(2)分别设置权值 p 和 $(1-p)$, 寻求最优。然后描述结果随着 W/L 和 p 的值的变化的变化是如何变化的。

除了撰写 MCM 论文之外, 你还要为新一期巧克力蛋糕美食杂志准备一个一至两页的广告, 阐述你的设计和结果的亮点所在。

MCM 2013 Problem B: Water, Water, Everywhere

Fresh water is the limiting constraint for development in much of the world. Build a mathematical model for determining an effective, feasible, and cost-efficient water strategy for 2013 to meet the projected water needs of [pick one country from the list below] in 2025, and identify the best water strategy. In particular, your mathematical model must address storage and movement; de-salinization; and conservation. If possible, use your model to discuss the economic, physical, and environmental implications of your strategy. Provide a non-technical position paper to governmental leadership outlining your approach, its feasibility and costs, and why it is the “best water strategy choice.”

Countries: United States, China, Russia, Egypt, or Saudi Arabia

MCM 2013 问题-B：水，水，无处不在

淡水资源是世界上许多地方持续发展的限制因素。建立数学模型来确定一个有效的，可行的，低成本的 2013 年用水计划，来满足某国(从下方的列表选择一个国家)未来(2025 年)的用水需求，并确定最优的淡水分配计划。特别的，你的数学模型必须包括储存、运输、淡化和节水等环节。如果可能的话，用你的模型来讨论你的计划对经济，自然和环境的影响。提供一个非技术性的意见书给政府领导概述你的方法，以及方法的可行性和成本，以及它为什么是“最好的用水计划的选择”。

国家：美国、中国、俄罗斯、埃及或者沙特阿拉伯。

ICM2013 问题-C：地球健康的网络模型

背景：社会对于发展和利用模型去预测地球的生物和环境的健康条件很有兴趣。很多科学研究都得出结论——越来越多的压力被施加在地球的环境和生物系统，但是很少有全球的模型去检测这些主张。UN 发现将近三分之二的地球生命供应生态系统——包括清洁的水，纯净的空气，稳定的气候，正在由于不可证实的用途而退化。人们因为这些破坏而受到指责。猛涨的对于食物，新鲜水，燃料，木材的需求对巨大的环境改变有重要影响，从砍伐森林到空气土地和水污染。不管对于当地栖息地和地区因素的相当大的研究，现在的模型都不能完全地告知决策者他们的地区性政策能怎样影响全球的健康。很多模型忽略了复杂的全球因素并且不能确定潜在政策的长期影响。尽管科学界明白大量的环境和生物系统的复杂的关系和交叉效应对于地球生态圈的影响，现在的模型经常忽略这些关系或者限制系统之间的联系。系统的复杂性表现在多样的交互作用，反馈回路，应激反应和即将发生情况的转变或者临界点。《自然》最新的由 22 名知名的国际科学家撰写的文章“地球生态圈的临界转换”概括了很多问题和对于科学模型的需求

与预测行星健康系统潜在变化的重要性。该文章提供了两种特殊的定量的建模，并向更好的预测模型提出挑战。

1、通过全球模型（包含复杂的地球相互关联的系统和地区条件对于全球系统的系统的影响，反之亦然）去提高生物预测。

2、确定可以产生不健康的全球状态转换的因素并且展示如何运用有效的生态系统管理方法去阻止或者限制这些即将发生的状态转变。

这个问题就是我们能否运用当地或者地区的组成地球健康的部分信息建立一个全球的模型，而这些信息组成部分是可以推断国家潜在变化并且可以帮助决策者通过对地球健康潜在的影响规划出有效的政策。尽管许多警报都出现了，但是没有一个人能够知道地球是否是已经接近了临界点，或者说是否已经达到了一个极限的状态。

自然的杂志以及许多其他的期刊都指出在地球生态系统中存在许多的元素。（例如局部因素，全球影响，多维因素与联系，变化时间和空间规模）同样也有许多其他的因素包含以这个预测模型：人口，气候变化，土地利用类型，污染，大气化学，海洋化学，生物多样性，以及潜在的项目例如社会的不稳定以及经济的不稳定。古生物学家已经研究并建立了生态系统行为模型以及反映了先前环境的巨大变动和因此产生的基于历史的定性和定量的信息都可以为未来的潜在模型提供北京只是。然而人为因素在我们现在的生物环境中显著增长也应该值得我们注意。

你们是 ICM 团队的成员，你们将组织一个题目为“地球健康网络模型”的研讨会，并且你们的模型领导者已经提前要求你们在研讨会上，展示模型，分析模型。他需要你们的团队做如下的准备：

问题 1：根据影响地球健康的因素（你自己寻找方法），建立一个动态的全球化网络模型，目的是确定影响的条件（网络节点）并且大概连接他们（网络链接）以寻找关系，起到作用。由于这些影响因素的动态性是非常重要的，因此这个网络模型必须包含一个动态的元素，来允许该模型预测未来状态的卫生状况。例如：你的节点，可能包括：国家，大陆，海洋，栖息地，或这些的任意组合，亦或者是构成全球化模型的其他元素。你的链接可以代表一个节点或是对环境的影响，或者是长时间的物理元素的流动（例如污染）。你的健康因素可以是地球上的任何元素的条件，包括：人口，生物，环境，社会，政治，物理或化学条件。确定你模型中的所有元素，并且解释你制作模型的网络方法，节点实体，链接决定的科学依据。决定一个数据化模型，可以设置任何参数，并且解释当有用的数据来临是，你将如何测试你的模型。什么类型的数据可以来验证，或验证你的模型的有效性？（注：如果您没有足够的参数，确定参数进行验证，不要扔掉你的数据。你的领导意识到，在这个阶段，良好的创新意识和理论的重要性基于数据模型的验证。）确定你包括人的因素在你的建模当中，并且解释人类行为和政府政策可能影响你的模型的结果。

问题 2：运行你的模型来看它如何预测地球未来的健康。你可能需要去检查你从数据中确定的参数。（记住，这只是检测和理解你建模的元素，不要用它去预测或者决策。）你的模型应该产生什么样的因素呢？它能够预测地球条件状况的改变或者临界点么？它能提供关于全球变化的地区条件的结果的警告么？它能告知决策者重要的政策么？你在测量和网络性能中考虑人为因素了么？

问题 3：运用网络模型的重要元素之一就是分析网络结构的能力。网络的特性可否帮助识别临界节点或者在模型中的关系？如果可以，请展示你的分析。你

的模型对于失去关联以及改变关系的敏感性如何？你的模型是否运用了反馈环节或者是否顾及到了不确定因素？收集了哪些信息？你的模型是否反映了不同国家的政策？你的模型能否帮助国家提出计划呢？

问题 4：写一篇 20 页的报告（summersheet 不计入）阐述你的模型以及其潜能。确保写清模型优势和劣势的细节。你的管理者将运用你的报告作为接下来工作的主要题目并且如果该模型合适并且有独到的见解，他将让你当众呈现下面的计划。你加油！

2014 MCM Problems

MCM2014 Problem A: The Keep-Right-Except-To-Pass Rule

In countries where driving automobiles on the right is the rule (that is, USA, China and most other countries except for Great Britain, Australia, and some former British colonies), multi-lane freeways often employ a rule that requires drivers to drive in the right-most lane unless they are passing another vehicle, in which case they move one lane to the left, pass, and return to their former travel lane.

Build and analyze a mathematical model to analyze the performance of this rule in light and heavy traffic. You may wish to examine tradeoffs between traffic flow and safety, the role of under- or over-posted speed limits (that is, speed limits that are too low or too high), and/or other factors that may not be explicitly called out in this problem statement. Is this rule effective in promoting better traffic flow? If not, suggest and analyze alternatives (to include possibly no rule of this kind at all) that might promote greater traffic flow, safety, and/or other factors that you deem important.

In countries where driving automobiles on the left is the norm, argue whether or not your solution can be carried over with a simple change of orientation, or would additional requirements be needed.

Lastly, the rule as stated above relies upon human judgment for compliance. If vehicle transportation on the same roadway was fully under the control of an intelligent system – either part of the road network or imbedded in the design of all vehicles using the roadway – to what extent would this change the results of your earlier analysis?

MCM 2014 问题-A：除非超车否则靠右行驶的交通规则

在一些汽车靠右行驶的国家（比如美国，中国等等），多车道的高速公路常常遵循以下原则：司机必须在最右侧驾驶，除非他们正在超车，超车时必须先移到左侧车道在超车后再返回。

建立数学模型来分析这条规则在低负荷和高负荷状态下的交通路况的表现。你不妨考察一下流量和安全的权衡问题，车速过高过低的限制，或者这个问题陈

述中可能出现的其他因素。这条规则在提升车流量的方面是否有效？如果不是，提出能够提升车流量、安全系数或其他因素的替代品（包括完全没有这种规律）并加以分析。

在一些国家，汽车靠左形式是常态，探讨你的解决方案是否稍作修改即可适用，或者需要一些额外的需要。

最后，以上规则依赖于人的判断，如果相同规则的交通运输完全在智能系统的控制下，无论是部分网络还是嵌入使用的车辆的设计，在何种程度上会修改你前面的结果？

MCM 2014 Problem B: College Coaching Legends

Sports Illustrated, a magazine for sports enthusiasts, is looking for the “best all time college coach” male or female for the previous century. Build a mathematical model to choose the best college coach or coaches (past or present) from among either male or female coaches in such sports as college hockey or field hockey, football, baseball or softball, basketball, or soccer. Does it make a difference which time line horizon that you use in your analysis, i.e., does coaching in 1913 differ from coaching in 2013? Clearly articulate your metrics for assessment. Discuss how your model can be applied in general across both genders and all possible sports. Present your model’s top 5 coaches in each of 3 different sports.

In addition to the MCM format and requirements, prepare a 1-2 page article for Sports Illustrated that explains your results and includes a non-technical explanation of your mathematical model that sports fans will understand.

MCM 2014 问题-B：大学教练传奇

体育画报是一个为运动爱好者服务的杂志，正在寻找在整个上个世纪的“史上最好的大学教练”。建立数学模型选择大学中在一下体育项目中最好的教练：曲棍球或场地曲棍球，橄榄球，棒球或垒球，篮球，足球。

时间轴在你的分析中是否会有影响？比如 1913 年的教练和 2013 年的教练是否会有所不同？清晰的对你的指标进行评估，讨论一下你的模型应用在跨越性别和所有可能对体育项目中的效果。展示你的模型中的在三种不同体育项目中的前五名教练。

除了传统的 MCM 格式，准备一个 1 到 2 页的文章给体育画报，解释你的结果和包括一个体育迷都明白的数学模型的非技术性解释。

ICM 2014 问题-C: 网络科学出版物的清单

考量(一些因素)对学术研究影像的一个技术是:建立和衡量研究引用的性质(properties)和合作者(co-author)的网络。合作完成一分手稿通常暗含着研究者之间强烈的相互影响。最著名的学术合作者之一是 20 世纪的数学家 Erdős, 他有超过 500 个合作者, 并且发表了超过 1400 篇技术研究论文。讽刺的是,或者不是, Erdős 也是对建立跨学科研究的最有影响力的奠基者之一。特别是 1959 年他与 Alfred Rényi 出版的论文“On Random Graphs”。Erdős 作为合作者的角色在数学领域非常重要以至于数学家通常衡量他们与 Erdős's 的亲密度通过分析 Erdős 的庞大和长久稳固(robust)的合著者网(<http://www.oakland.edu/enp/>)。这个不寻常的和迷人的 Erdős 的故事,讲述了 Erdős 作为一个有天赋的数学家,优秀的问题解决者和主导合作者(master collaborator)在许多书籍和在线网站都有提供:

也许是他流浪的生活方式,频繁的和他的合作者呆在一起,并且给他的学生奖金作为解决问题的奖励,使得他的作者协作关系兴旺发达并且帮助他建立了令人震惊的几个数学领域的影响力网络。为了衡量 Erdős 产生的这种影响,这里有几个基于网络的工具:使用了合作者和引文数据来决定研究者、出版者和期刊的影响因素。这里面的一些有:科学文献索引、健康要素、影响因素、特征因子等。谷歌学术搜索也是一个很好的数据工具 用来收集和分析网络的影响数据。你们小组的目标是分析在社会其他领域的影响和冲击。你们的任务包括:

1. 建立 Erdős authors 的合作者网络(你可以使用网站 <https://files.oakland.edu/users/grossman/enp/Erdos1.html> 或者一个 Erdos1.htm 中的网站)。你需要从 Erdos1 的文件中建立大约 510 个同 Erdos1 有合著论文关系的研究人员(不包括 Erdős)的合作者网络。这需要用一些技术数据抽取和模型支持去获得一系列正确的节点(Erdős 的合著者)和他们的关系(同一个作为合著者的作者的联系)。这里有超过 18000 条原始数据在 Erdos1 文件,但是他们中很多不需要用到,因为他们是 Erdos1 文件中外界的人员关系。如果必要的话,你可以限制你分析的网络的大小,为了调整你的影响测量算法。一旦建立,分析这个网络的内容(注意,不要包括 Erdős,他是最有影响力的,而且会与网络中所有节点都有关。在这个案例中,是用与他有关的合作者来建立网络,但是他不是网络或者分析中的一部分。)

2. 建立影响测量,来决定谁是 Erdos1 网络中影响力最重要的。考虑谁曾经发表过重要的著作或者与 Erdos1 中重要的研究人员有联系。注意,假设 Erdős 不在其中扮演任何角色。

3. 另一种衡量影响的方式可能是分析这篇调查报告发表以后紧跟着的重要的作品。选择一些在重要的网络科学领域的基础性文献,从附录(NetSciFoundation.pdf)或者你自己找。用这些文献来分析并建立一个模型来决定他们的相关关系。建立影响网络(合作者或引文)并为你的分析计算合适的测量方式。在你选择的这批论文里面你认为哪个是最具影响力的网络科学,为什么?这里有没有一种相似的方式来决定一个独立的网络研究人员的角色和影响?考虑你如何来衡量一个特定的大学、部门、或者一个期刊在网络科学里的角色、影响、或冲击?讨论进行这种衡量的方法和需要收集的数据。

4. 将你的算法运用在一系列完全不同的网络影响数据上

--例如,有影响的作曲家、音乐乐队,表演者,电影演员,导演、电影、电视节目、专栏作家、记者、报纸、杂志、小说家,小说、博客、推特或任何你愿意分析的数据集。你可能要限制网络的特定类型或地理位置或预定的大小。

5. 最后,讨论科学、理解和模型的影响和冲击在网络内部的效用。个人、组织、国家和社会可以使用这种影响方法(influence methodology)去改善人际关系,做生意,和做出明智的决

定吗?例如,在个体层面,描述如何使用你的措施和算法选择和谁合作来尽快提高你的数学的影响力 (mathematical influence)。或者你如何使用你的模型和结果为你未来的学术工作来对毕业学校或导师做出选择?

6. 写一个报告,解释你的模型的方法论,你基于网络的影响和冲击测量,和你的前五个任务的过程和结果。这个报告不能超过 20 页 (不包括你的总结页),而且要展示你的网络数据的坚实分析,优势和缺点,你的方法的,模型的灵敏度。

这是一个可能被包括在基础性有影响的网络科学出版物的清单。网络科学是一个新的,重要的,多种多样的,各学科间的领域。所以,没有大量的,集中的期刊可以很简单地被用来寻找网络科学的文献,即使好几个新的期刊最近刚被建立,并且新的在网络科学领域的学术项目在世界范围内的大学中开始开展。你可以为你们的队伍自由选择使用这里的一些文献来分析和比较网络科学的影响 (for 任务 3)

MCM2015 Problem A: Eradicating Ebola

The world medical association has announced that their new medication could stop Ebola and cure patients whose disease is not advanced. Build a realistic, sensible, and useful model that considers not only the spread of the disease, the quantity of the medicine needed, possible feasible delivery systems, locations of delivery, speed of manufacturing of the vaccine or drug, but also any other critical factors your team considers necessary as part of the model to optimize the eradication of Ebola, or at least its current strain. In addition to your modeling approach for the contest, prepare a 1-2 page non-technical letter for the world medical association to use in their announcement.

MCM2015 问题-A: 根除埃博拉病毒

世界医学协会已经宣布他们的新药物能阻止埃博拉病毒并且可以治愈一些处于非晚期疾病患者。建立一个现实的,合理的并且有用的模型,该模型不仅考虑了疾病的蔓延,需要药物的量,可能可行的输送系统,输送的位置,疫苗或药物的生产速度,而且也要考虑其他重要的因素,诸如你的团队认为有必要作为模型的一部分来进行优化而使埃博拉病毒根除的一些因素,或者至少考虑当前的状态。除了你的用于比赛的建模方法外,为世界医学协会准备一份 1-2 页的非技术性的信,方便其在公告中使用。

MCM2015 Problem B: Searching for a lost plane

Recall the lost Malaysian flight MH370. Build a generic mathematical model that could assist "searchers" in planning a useful search for a lost plane feared to have crashed in open water such as the Atlantic, Pacific, Indian, Southern, or Arctic Ocean while flying from Point A to Point B. Assume that there are no signals from the downed plane. Your model should recognize that there

are many different types of planes for which we might be searching and that there are many different types of search planes, often using different electronics or sensors. Additionally, prepare a 1-2 page non-technical paper for the airlines to use in their press conferences concerning their plan for future searches.

MCM2015 问题-B: 寻找失踪的飞机

找回失踪的马来西亚航班 MH 370。建立一个通用的数学模型,可以帮助“搜索者”制定一个可用的针对失踪飞机的搜索方案,飞机在从 A 点到 B 点飞行中,恐怕已经坠毁在开放水域中,如大西洋,太平洋,印度洋,南太平洋,或北冰洋。假设无法获取到坠落飞机的任何信号。你的模型应该认识到我们搜索的有许多不同类型的飞机,而且有许多不同类型的搜索飞机,这些飞机通常使用不同的电子设备或传感器。另外,为航空公司准备一个 1-2 页的非技术报告,用于他们未来的搜索计划的新闻发布会。

ICM2015 问题-C: 组织机构下的人力资本管理

建立这样一个组织,该组织的成员业务优秀,才华横溢,且训练有素,是该组织成功的关键因素之一。但是要做到这一点,该组织需要多招贤纳士,留得住人才,且使其接受良好的培训,做到才尽其用。从而谋求新的求职者去取代能力逊者。个人在组织中扮演着独特的角色,亦或正式亦或非正式。因此,职员离岗会造成组织重要信息功能部件的缺失,急待补充新鲜血液。就这一点上,任何体育团体,商业公司,各类学校,政府机构莫不如此。

人力资源(HR)专家帮助高层管理人员如何留得住好员工,如何恰当激励员工,协调培训从而最终建立一个优秀的团队。尤为重要,管理层应当寻求建立一个高效的组织机构,员工各尽其职,才尽其用,各体系沟通顺畅,激发产生更多创新性的理念和优质产品。这些优秀的管理团队,全方位打造人力资源的方方面面,不断重塑和造就了许许多多的现代企业集团。

在流动性极大的组织内部管理人力资源,需要深入了解员工对公司以及所属机构的忠诚度。在工作地建立信任的氛围,积极有效地进行管理,从容应对员工的去留问题,协调员工间的融洽关系。当员工离职或退休需要被替换时,组织内部产生剧烈的效应被称之为“人才流失后遗症”。人力资源经理会要求公司组织去开发框架和模型从而分析人才流失现象对有 370 人的 ICM 所产生的影响。ICM 存在于一个具有高度竞争意识的市场,往往导致一系列具有挑战性的问题的产生,皆与如何有效地进行人力资源管理息息相关。

通过构建网络模型,人力资源经理可以测绘组织机构中的人力资本。下面列出的贵公司可能面临的问题。

1、ICM 旨在识别人才流失早期的风险,因为早期可以较容易地获得员工对公司的忠诚度,而不是在事情变糟糕后想着去弥补。从一开始应该对员工进行更富有成效的激励,而不是为阻止人们离开提供各种激励措施。

2、员工会产生人才流失后遗症效应,这种效应有可能会传染到其他员工身上。因此,人力部门应该了解这部分员工的信息,获取有价值的线索而不是盲目阻止。

3、人力的最大资源问题是如何做到才尽其用。使员工的知识 and 能力实现最大化。每个员工应该得到主管给出的年度评估,该评估可以用到人力资源管理上。而目前却没有。

4、ICM 认识到中层管理人员(初级经理,经验丰富监事、没有经验的监事)经常感到无力,难以获得提升的机会,迫使他们离开就职的公司另谋高就。而这些离职缺失的中层职位至关重要,与之连带的是高营业额(其他公司的平均水平的两倍),这似乎是个急切需要填充的问题。

5、招聘优秀人才是困难的、耗时和昂贵的。ICM, 370 个职位里,通常有 85% 的职位在岗。因为行政延迟和办公能力和内部晋升等问题,人力资源办公室正在积极招聘大约 8 - 10% 的 ICM 职位(大约 2/3 的当前职位空缺)。

6、为了迈入到更高的管理级别,员工往往需要数年的经验,在公司的各个层次和岗位上进行积累。这可能会为人力资源部门引发诸多棘手的问题和障碍。

7、流失率一直在稳步增加,尤其是中层管理人员。ICM 的人力资源经理认为这是该公司面临的最大的挑战。每每听说目前人才流失率是每年 18%, 首席执行官总是感到惊慌失措。

8、因为 ICM 总是担心人手不足,边缘化和产效低下的员工留在了公司,这样,几乎很少有员工被免职或解雇。他们可能终其一生呆在同一个公司里。质量效益与管理有着莫大的关系,但在此条件下,难觅良策。

9、组织内部,贵公司往往可以自豪的是贵公司的 CEO 和员工工资之比是良性的,可以接受的(CEO 的薪水大约是 10 倍的员工平均工资,与此同时这个比率在其他公司可能是 100 倍或更多)

ICM 人力资源经理最近整合了一张综合性组织图表(图 1)和详细的统计数据,来描述公司的基本结构、人员构成、招募成本、培训成本以及公司员工的工资(表 1)。该公司以前从没有进行过类似的分析、建模或者提升人力资源功能效用。因此,该经理认为,是时候使用计算机网络科学技术来自动调控和分析 ICM 人力资源构成要素了。

图 1: 严格的结构以及高监管特性的 ICM 有一些必要条件: 每个员工办公室或分支机构都包括含有 7 人的两组人员构成,要不然抑或是该表格中每条目没有含有 4 名员工的条目。因此 370 名员工被分别安排在 7 人组成的 46 个分支机构和 4 人组成的 12 个分支办公室里。

表 1: 人力资源经理会向您提供一些重要的数据包括员工的人数和员工的级别、平均工资、以及对外招募的平均成本和时间来匹配和对应各个层次的员工以及年度培训成本等诸项事宜。公司的中等收入被定性为 σ 。ICM 中 σ 的价值会随着通胀率缓慢上升。因此所有 ICM 的决策者对于报告和各项决策感到相对适应。而这些报告和决策是建立在不断变化抑或是相对的 σ 的价值,而不是货币的确切价值。

Tasks: 任务

公司的人力资源经理所面临的工作任务和研究问题如下:

1) 使用提供的数据, 建立一个在 ICM 组织人力工作情境下的人力资本网络模型。你可以大胆的假设去建立模型, 务必清晰的描述模型和你的推测和假设。

2) 使用你的模型去鉴定和识别人力资本网络中的动态过程, 描述和整合动态过程, 此过程包括: 1. 机构性人才流失(以及影响或造成的不满) 2. 对公司生产力直接或间接的影响, 你可以做大胆推测和假设来解释这些过程, 来描述你的模型和你所有的假设。

3) 通过 σ 的方式, 使用你的模型去分析贵公司对于人才管理的预算成本和条件, 以备未来两年之内的招募和培训之用。

4) 如果年度人才流失率达到 25%, ICM 还能维持各个职位满员 80% 的水平吗? 达到 35% 又会怎么样? 这两种较高的比率所带来的相关成本是什么? 高人才流失率间接带来的影响是什么?

5) ICM 人力资源主管想要使用贵公司的模型模拟, 流失率达到 30% 所产生的影响, 涉及

到高级主管、有经验的监管人员、不进行外部招聘，未来两年只提升那些有资质的员工。在你的模型中，其他人才流失率值应该保持在 18%。向人力资源经理解释健康的人力资源组织机构所带来的影响。

6) 贵公司的主管可能要求此种有才能的管理方式及所谓的团队科学。在你创模之时，会向你提供以下参考资料。

- E. Salas, N.J. Cooke, and M.A. Rosen. (2008). On Teams, Teamwork, and Team Performance: Discoveries and Developments. *Human Factors: The Journal of the Human Factors and Ergonomics Society* June 2008 vol. 50 no. 3 540-547.
- D. Stokols, K.L. Hall, B.K. Taylor, R.P. Moser (2008). The Science of Team Science: Overview of the Field and Introduction to the Supplement, *Am J Prev Med* 2008; 35(2S): S77-S89

最终的目的是，人力资源经理最终想要把你所创立的人力资本网络连接到其他组织网络层面上。比如：信息流、相互间的信任、影响、友谊等。凡此种种，都是其他 ICM 的办公室一直在考虑建立的网络。人力资源经理的希望是，人力资源办公室应当带头努力实施，从而连接公司的各个网络模型，并且殷切希望你的团队能够帮他实现这一愿景。基于上述考虑，人力资源经理提供以下参考资料：

- Mikko Kivelä, Alexandre Arenas, Marc Barthelemy, James P. Gleeson, Yamir Moreno, Mason A. Porter. (2013). Multilayer Networks, *J. Complex Networks*, 2(3): 203-271 (2014); arXiv preprint arXiv:1309.7233, 2013.

概括团队科学和多层网络的潜在用途，实现人力资源经理的希望。

7) 写一份 20 页的报告来陈述你的组织模型，和它的功能以及主管要求考虑的诸多问题。一页的执行摘要不计算在内，此外，所提报告最多只能为 21 页。

ICM2015 问题-D： 这是可持续的吗？

问题背景

我们时代的一个最大的挑战是如何处理日益增加的人口和消费与地球有限资源的之间的矛盾。我们如何在增加股本的同时，消除贫困？自从十九世纪六十年代的现代环境运动的开始，平衡人的需求与地球的健康是一个有相当大的争论的话题。经济发展和生态系统的健康是相抵触的吗？为了调节这种不平衡，可持续发展的概念在上世纪 80 年代被引入。可持续发展的定义是在 1987 布伦特兰报告中第一次引出的，定义为“可持续发展：既满足当代人的需求又不损害后代人满足其自身需求的能力。”自从该概念提出以来，可持续发展已成为国际援助机构，目标规划机构，政府，非营利组织的目标。尽管如此，追求一个可持续发展的未来从来没有变得更紧迫。联合国预测，世界人口将在 2050 年达到 90 亿人。这些人口再加上消费的增加，给地球上有限资源带来了显著的压力。认识到地球是一个连接时间和空间系统是可持续发展的关键。发展必须关注需要（例如，减少世界贫困人口脆弱性）和限制（例如，环境对废物的解毒能力）。在 2012 年可持续发展的联合国会议上提出：“消除贫困，改变不可持续的方式进而促进可持续消费模式和生产，保护和管理经济和社会发展的自然资源基础，是可持续发展的首要目标和基本要求。“减少个人的贫困和脆弱性，鼓励经济发展，和维持生态系统健康是可持续发展的支柱。

问题陈述

国际货币基金组织（IMF）雇佣你来帮助他们运用他们已有的丰富金融资源和影响力，创造一个可持续发展的世界。他们对发展中国家特别感兴趣，在那里他们相信可以获得最大的投资回报。

任务 1：建立一个国家的可持续发展模型。这种模式应该提供衡量方法以区分哪些国家和政策是可持续的。它也可以告知 IMF 哪些是最需要支持和干预的国家。一些因素可能包括人类健康，食品安全，干净的饮用水的获取，当地环境质量，能源获取，生计，社会的脆弱性，和平的可持续发展。你的模型应该明确何时以及如何确定一个国家是否是可持续发展。

任务 2：从联合国所列的 48 个最不发达国家（LDC）中选择一个国家（<http://unctad.org/en/pages/alcd/Least%20Developed%20Countries/UN-list-of-Least-Developed-Countries.aspx>）。使用从任务 1 中你的模型和研究，为您选定的 LDC 国家创建一个 20 年的可持续发展计划从而使其走向一个更可持续的未来。该计划应包括项目，政策，和援助。该援助可由 IMF 在一国之内根据他们的人口，自然资源，经济，社会和政治条件进行提供。

任务 3：评估你的 20 年的可持续发展计划对你的国家在任务 1 中创建的可持续发展措施的有效性。预测在你的评价体系下实施你的计划后发生在未来 20 年中的变化。基于所选择的国家，你可能需要考虑其他环境因素，如气候变化，发展援助，外国投资，自然灾害，以及政权的不稳定情况。IMF 想得到“最划算”的投资，所以确定哪些项目或政策对你的国家的可持续发展措施会产生最大的效果。确定将要实施的高效的战略手段是为了 IMF 的终极目标——创造一个可持续发展的世界。

任务 4：写一个 20 页的报告（摘要页不计在 20 页之内）来解释你的模型，你的可持续发展措施，您的可持续发展计划，根据你的模型和国家的环境情况，分析你的计划的效果。一定要详细的解释你的模型的优点和缺点。IMF 将使用您的报告用于投资特定的 LDC 国家并进行可持续发展的干预策略。

可能用到的资源

UN sustainable development knowledge platform (<http://sustainabledevelopment.un.org>)

Ecological

footprint (http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_basics_overview/)

World Bank Data (<http://data.worldbank.org>)

International Institute for Sustainable Development (<https://www.iisd.org/sd/>)

UN sustainable development knowledge platform（联合国可持续发展知识平台）

<http://sustainabledevelopment.un.org>

Ecological footprint（生态足迹网站）

(http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_basics_overview/)

World Bank Data（世界银行数据）(<http://data.worldbank.org>)

International Institute for Sustainable Development（国际可持续发展机构）(<https://www.iisd.org/sd/>)

World Commission on Environment and Development (WCED). 1987. Our Common Future. New York: Oxford University Press, 1987, 8.

United Nations. The future we want. Resolution adopted by the General Assembly. 66th Session of the General Assembly, 123rd plenary meeting; 2012 July 27. New York: UN; 2012 Sep 11 (Resolution A/RES/66/288) [cited 2013 Jul 23]. Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/66/288&Lang=E.

Other useful Sources

Bell, Simon and Stephen Morse. 2008. Sustainability Indicators: measuring the immeasurable.

Earthscan, London.

Daly, Herman. 1990. Towards some operational principles of sustainable development. *Ecological Economics*, 2(1990) 1-6.

Kates, Robert W., Thomas M. Parris, and Anthony A. Leiserowitz. 2005. What is sustainable Development: Goals indicators, values, and practices. *Environment: Science and Policy for Sustainable Development*, Volume 47, Number 3, pages 8–21.

MCM2016 Problem A A Hot Bath

A person fills a bathtub with hot water from a single faucet and settles into the bathtub to cleanse and relax. Unfortunately, the bathtub is not a spa-style tub with a secondary heating system and circulating jets, but rather a simple water containment vessel. After a while, the bath gets noticeably cooler, so the person adds a constant trickle of hot water from the faucet to reheat the bathing water. The bathtub is designed in such a way that when the tub reaches its capacity, excess water escapes through an overflow drain.

Develop a model of the temperature of the bathtub water in space and time to determine the best strategy the person in the bathtub can adopt to keep the temperature even throughout the bathtub and as close as possible to the initial temperature without wasting too much water.

Use your model to determine the extent to which your strategy depends upon the shape and volume of the tub, the shape/volume/temperature of the person in the bathtub, and the motions made by the person in the bathtub. If the person used a bubble bath additive while initially filling the bathtub to assist in cleansing, how would this affect your model's results?

In addition to the required one-page summary for your MCM submission, your report must include a one-page non-technical explanation for users of the bathtub that describes your strategy while explaining why it is so difficult to get an evenly maintained temperature throughout the bath water.

MCM2016 问题- A 热水澡

一个人用热水通过一个水龙头来注满一个浴缸，然后坐在浴缸中，清洗和放松。不幸的是，浴缸不是一个带有二次加热系统和循环喷流的温泉式浴缸，而是一个简单的水容器。过一会儿，洗澡水就会明显地变凉，所以洗澡的人需要不停地将热水从水龙头注入以加热洗浴水。该浴缸的设计是以这样一种方式，当浴缸里的水达到容量极限，多余的水通过溢流口泄流。考虑空间和时间等因素，建立一个浴缸的水温模型，以确定最佳的策略，使浴缸里的人可以用这个模型来让整个浴缸保持或尽可能接近初始的温度，而不浪费太多的水。

使用你的模型来确定你的策略对浴缸的形状和体积，浴缸里的人的形状、体积、温度，以及浴缸中的人的运动等因素的依赖程度。如果这个人一开始用了一种泡泡浴剂加入浴缸，以协助清洗，这会怎样影响你的模型的结果？除了要求的一页 MCM 摘要提交之外，你的报告必须包括一页的为浴缸用户准备的非技术性的说明书来阐释你的策略，同时解释

为什么洗澡水的温度得到均衡地保持是如此之难。

MCM2016 Problem B Space Junk

The amount of small debris in orbit around earth has been a growing concern. It is estimated that more than 500,000 pieces of space debris, also called orbital debris, are currently being tracked as potential hazards to space craft. The issue itself became more widely discussed in the news media when the Russian satellite Kosmos-2251 and the USA satellite Iridium-33 collided on 10 February, 2009.

A number of methods to remove the debris have been proposed. These methods include small, space-based water jets and high energy lasers used to target specific pieces of debris and large satellites designed to sweep up the debris, among others. The debris ranges in size and mass from paint flakes to abandoned satellites. The debris' high velocity orbits make capture difficult. Develop a time-dependent model to determine the best alternative or combination of alternatives that a private firm could adopt as a commercial opportunity to address the space debris problem. Your model should include quantitative and/or qualitative estimates of costs, risks, benefits, as well as other important factors. Your model should be able to assess independent alternatives as well as combinations of alternatives and be able to explore a variety of important "What if?" scenarios.

Using your model, determine whether an economically attractive opportunity exists or no such opportunity is possible. If a viable commercial opportunity exists as an alternative solution, provide a comparison of the different options for removing debris, and include a specific recommendation as to how the debris should be removed. If no such opportunity is possible, then provide innovative alternatives for avoiding collisions.

In addition to the required one-page summary for your MCM submission, your report must include a two-page Executive Summary that describes the options considered and major modeling results, and provides a recommendation for a particular action, combination of actions, or no action, as appropriate from your work. The Executive Summary should be written for high level policy makers and news media analysts who do not have a technical background.

MCM2016 问题-B 太空垃圾

在地球轨道上的小碎片的数量已引起越来越多的关注。据估计，目前有超过 500,000 块的空间碎片，也被称为轨道碎片，由于被认为对空间飞行器是潜在的威胁而正在被跟踪。2009 年 2 月 10 日，俄罗斯卫星 kosmos-2251 和美国卫星 iridium-33 相撞之后，该问题受到了新闻媒体更广泛的讨论。

一些消除碎片方法已经被提出。这些方法包括使用微型的基于太空的喷水飞机和高能量的激光来针对一些特定的碎片和设计大型卫星来清扫碎片。碎片

按照大小和质量分步，从刷了油漆的薄片到废弃的卫星都有。碎片在轨道上的高速度飞行使得捕捉十分困难。

建立一个以时间为考量的模型，以确定最佳的方法或系列方法，为一个私营企业提供商机以解决空间碎片问题。你的模型应该包括定量和定性的对成本，风险，收益的估计，并考虑其他的一些重要因素。你的模型应该能够评估某种方法，以及组合的系列方法，并能够研究各种重要的假设情况。

使用你的模型，确定商机会是否存在。如果存在可行的不同种类的解决方案，比较不同的去除碎片的方案，该方案包括一个具体的建议来说明如何消除碎片。如果没有这种可能，请提供创新性的方案来消除碰撞。

除了 MCM 要求提交的一页摘要外，由于高层政策制定者和新闻媒体分析人士不具备技术背景，所以你应写出一个执行报告。必须包括一个两页的执行报告，该报告介绍了考虑的方案和主要的建模结果，并且该报告还要从你的前面所做的工作中提出一个合理的行动建议，包括单一具体的行动，联合行动，或不采取行动。

MCM2016 Problem 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 (US\$100 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 (ProblemC.DAT) 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 defensible 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-09-082015.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>

MCM2016 问题-C goodgrant 的挑战

goodgrant 基金会是一个慈善组织，其目的是提高高校就读的美国本科生教育绩效。为此，基金会计划从 2016 年 7 月开始的五年中每年捐赠 1 亿美元到符合条件的学校。在这样做时，他们不想重复投资和关注其他大型的捐赠组织如盖茨基金会和基金会所。

goodgrant 基金会要求你的团队建立一个模型来确定最优投资策略，以确定需要投资的学校、每个学校的投资额、这项投资的回报、对学生成绩有显著的正向影响所需要持续的投资时间。这一策略应该包含一个 1 到 n 的最优化，以及优先推荐学校的列表，而这些学校的选择是基于每个候选学校所表明的能有效利用私人资金投资、有潜力的学校候选名单。此外，你的策略还应包括适合诸如 goodgrant 基金组织投资的预估的投资回报。

助你一臂之力，附录的数据文件（problemcdata.zip）包含来自美国国家教育统计中心（www.nces.ed.gov/ipeds）提取的信息。它包含一个广泛的几乎所有的大学在美国的调查信息数据库，和大学记分卡数据集（包含 <https://collegescorecard.ed.gov>），各种制度绩效数据。你的模型和随后的策略必须基于一些有意义且可靠的这两个数据集的子集。

除了 MCM 要求提交的一页摘要外，你的报告必须包括给 goodgrant 基金会首席财务官（CFO）Mr.AlphaChiang 的一封信，描述你的最优投资策略，你的建模方法和主要结果，并简要地讨论你提出的投资回报，以便于让 goodgrant 基金会采用，来评估 2016 年的捐款和未来在美国的慈善教育投资。这封信的长度不超过 2 页。

注意：提交你的电子解决方案时不包含任何数据库文件。应提交的唯一的東西就是你的电子（Word 或 PDF）解决方案。

ProblemCdata.zip 数据文件包含：

问题 C-美国 UID 为潜在的候选学校.xlsx

问题 C 最新研究的数据（记分卡要素）。xlsx

问题 C 记分卡数据词典-09-08-2015.xlsx

IPEDS 变量列表.pdf

你可以下载数据（problemcdata.zip）在以下网站：

<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>

ICM 2016 Problem D Measuring the Evolution and Influence in Society's Information Networks

Information is spread quickly in today's tech-connected communications network; sometimes it is due to the inherent value of the information itself, and other times it is due to the information finding its way to influential or central network nodes that accelerate its spread through social media. While content has varied -- in the 1800s, news was more about local events (e.g., weddings, storms, deaths) rather than viral videos of cats or social lives of entertainers -- the prevailing premise is that this cultural characteristic to share information (both serious and trivial) has always been there. However, the flow of information has never been as easy or wide-ranging as it is today, allowing news of various levels of importance to spread quickly across the globe in our tech connected world. By taking a historical perspective of flow of information relative to inherent value of information, the Institute of Communication Media (ICM) seeks to understand the evolution of the methodology, purpose, and functionality of society's networks. Specifically, your team, as part of ICM's Information Analytics Division, has been assigned to analyze the relationship between speed/flow of information vs inherent value of information based on consideration of 5 periods: in the 1870s, when newspapers were delivered by trains and stories were passed by telegraph; in the 1920s, when radios became a more common household item; in the 1970s, when televisions were in most homes; in the 1990s, when households began connecting to the early internet; in the 2010s, when we can carry a connection to the world on our phones. Your supervisor reminds you to be sure to report the assumptions you make and the data you use to build your models.

Your specific tasks are:

- (a) Develop one or more model(s) that allow(s) you to explore the flow of information and filter or find what qualifies as news.
- (b) Validate your model's reliability by using data from the past and the prediction capability of your model to predict the information communication situation for today and compare that with today's reality.
- (c) Use your model to predict the communication networks' relationships and capacities around the year 2050.
- (d) Use the theories and concepts of information influence on networks to model how public interest and opinion can be changed through information networks in today's connected world.

(e) Determine how information value, people's initial opinion and bias, form of the message or its source, and the topology or strength of the information network in a region, country, or worldwide could be used to spread information and influence public opinion.

Possible Data Sources:

As you develop your model and prepare to test it, you will need to assemble a collection of data. Below are just some examples of the types of data you may find useful in this project. Depending on your exact model, some types of data may be very important and others may be entirely irrelevant. In addition to the sample sources provided below, you might want to consider a few important world events throughout history – if some recent big news events, such as the rumors of country-turned-pop singer Taylor Swift's possible engagement had instead happened in 1860, what percentage of the population would know about it and how quickly; likewise, if an important person was assassinated today, how would that news spread? How might that compare to the news of US President Abraham Lincoln's assassination?

Sample Circulation Data and Media Availability:

http://media-cmi.com/downloads/Sixty_Years_Daily_Newspaper_Circulation_Trends_050611.pdf

<http://news.bbc.co.uk/2/hi/technology/8552410.stm>

<http://www.gov.scot/Publications/2006/01/12104731/6>

<http://www.technologyreview.com/news/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history/>

<http://newsroom.fb.com/content/default.aspx?NewsAreaId=22>

<http://www.poynter.org/news/mediawire/189819/pew-tv-viewing-habit-grays-as-digital-news-consumption-tops-print-radio/>

<http://www.people-press.org/2012/09/27/section-1-watching-reading-and-listening-to-the-news-3/>

<http://theconversation.com/hard-evidence-how-does-false-information-spread-online-25567>

Historical Perspectives of News and Media:

<https://www.quora.com/How-did-news-get-around-the-world-before-the-invention-of-newspapers-and-other-media>

<http://2012books.lardbucket.org/books/a-primer-on-communication-studies/s15-media-technology-and-communication.html>

<http://firstmonday.org/article/view/885/794>

Richard Campbell, Christopher R. Martin, and Bettina Fabos, *Media & Culture: An*

Introduction to Mass Communication, 5th ed. (Boston, MA: Bedford St. Martin's, 2007)

Marshall T. Poe, *A History of Communications: Media and Society from the Evolution of Speech to the Internet* (New York: Cambridge, 2011)

Shirley Biagi, *Media/Impact: An Introduction to Mass Media* (Boston, MA: Wadsworth, 2007)

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

ICM2016 问题-D 社会信息网络的演变和影响评估

在当今技术通信网络中，信息迅速传播；有时是由于信息本身的内在价值，其他时候是由于信息到达有影响或中心的网络节点，能够通过社交媒体加快其传播。虽然内容不同，在 19 世纪，新闻更多关于当地事件（如婚礼、暴雨、死亡），而不是猫或艺人的社会生活的视频。主流的假设是，共享信息这种文化特征一直存在（包括严肃的和琐碎的）。然而，信息传播从未像现在一样，如此简单、广泛，在我们发达的通讯网络中，允许重要性不同的新闻在全球迅速蔓延。从历史角度看，信息传播与其内在价值相关，传媒研究所（ICM）寻求能够理解社会网络方法论、目的和功能的演变。

具体来说，作为 ICM 的信息分析部的一部分，您的团队任务是分析速度/信息流与信息内在价值的关系，考虑五个阶段：19 世纪 70 年代，报纸由火车散发，故事靠电报传播；20 世纪 20 年代，收音机是更常见的家用品；20 世纪 70 年代，电视出现在大多数家庭；20 世纪 90 年代，家庭连到早期的互联网；在 21 世纪前 10 年，我们可以靠手机连接世界。你的导师提醒你一定要证实你所做出的假设，用于建模的数据要可靠。

你们的特定任务是：

(a)开发一个或多个模型，使你能够探索信息流动，过滤或找到能成为新闻的内容。(b)利用过去的的数据验证模型的可靠性；预测今天的信息沟通情况，验证其预测能力，与今天的现实作对比。

(c)用你的模型预测 2050 年沟通网络的关系和能力。

(d)使用信息对网络影响的理论和概念，建模研究如何在今天的互联网世界中，让公共利益和观点通过信息网络得到改变。

(e)确定在一个国家、地区或世界范围内，信息价值，人们最初看法和偏见，消息形式或来源，和信息网络的拓扑结构或强度，如何被用来传播信息和影响公众舆论。

可能用到的数据来源：

当你建立模型后并准备验证，你需要收集数据。下面是一些你可能在这个项目中觉得有用的数据类型。根据你的具体的模型，某些类型的数据可能是非常重要的，其他的可能是完全无关的。除了下面提供的数据来源，你可能要考虑一些历史上发生的重要事件，如一些最近的重大新闻事件，假如传遍全国的谣言---流行歌手泰勒斯威夫特的订婚---发生在 1860 年，有多少比例的人口在多快的速度下将知道这一消息；同样，如果一个重要的人今天被暗杀了，这一消息将如何传播？如何将这一消息与美国总统亚伯拉罕·林肯被暗杀事件的新闻相比较？

样本循环数据和媒体的可用性：

http://media-cmi.com/downloads/Sixty_Years_Daily_Newspaper_Circulation_Trends_050611.pdf

<http://news.bbc.co.uk/2/hi/technology/8552410.stm>

<http://www.gov.scot/Publications/2006/01/12104731/6>

<http://www.technologyreview.com/news/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history/>

<http://newsroom.fb.com/content/default.aspx?NewsAreaId=22>

<http://www.poynter.org/news/mediawire/189819/pew-tv-viewing-habit-grays-as-digital-newsconsumption-tops-print-radio/>

<http://www.people-press.org/2012/09/27/section-1-watching-reading-and-listening-to-the-news-3/>

<http://theconversation.com/hard-evidence-how-does-false-information-spread-online-25567>

Historical Perspectives of News and Media:

<https://www.quora.com/How-did-news-get-around-the-world-before-the-invention-of-newspapers-and-other-media>

<http://2012books.lardbucket.org/books/a-primer-on-communication-studies/s15-media-technology-and-communication.html>

<http://firstmonday.org/article/view/885/794>

Richard Campbell, Christopher R. Martin, and Bettina Fabos, *Media & Culture: An Introduction to Mass Communication*, 5th ed. (Boston, MA: Bedford St. Martin's, 2007)

Marshall T. Poe, *A History of Communications: Media and Society from the Evolution of Speech to the Internet* (New York: Cambridge, 2011)

Shirley Biagi, *Media/Impact: An Introduction to Mass Media* (Boston, MA: Wadsworth, 2007)

你的 ICM 解决方案的内容包括 1 页的摘要和你的 20 页的解决方案，不能超过 21 页。

注：附录和参考资料不算在 20 页的限制内。

ICM 2016 Problem E Are we heading towards a thirsty planet?

Will the world run out of clean water? According to the United Nations, 1.6 billion people (one quarter of the world's population) experience water scarcity. Water use has been growing at twice the rate of population over the last century. Humans require water resources for industrial, agricultural, and residential purposes. There are two primary causes for water scarcity: physical scarcity and economic scarcity. Physical scarcity is where there is inadequate water in a region to meet demand. Economic scarcity is where water exists but poor management and lack of infrastructure limits the availability of clean water. Many scientists see this water scarcity problem becoming exacerbated with climate change and population increase. The fact that water use is increasing at twice the rate of population suggests that there is another cause of scarcity – is it increasing rates of personal consumption, or increasing rates of industrial consumption, or increasing pollution which depletes the supply of fresh water, or what? **

Is it possible to provide clean fresh water to all? The supply of water must take into account the physical availability of water (e.g., natural water source, technological advances such as desalination plants or rainwater harvesting techniques). Understanding water availability is an inherently interdisciplinary problem. One must not only understand the environmental constraints on water supply, but also how social factors influence availability and distribution of clean water. For example, lack of adequate sanitation can cause a decrease in water quality. Human population increase also places increased burden on the water supply within a region. When analyzing issues of water scarcity, the following types of questions must be considered. How have humans historically exacerbated or alleviated water scarcity? What are the geological, topographical, and ecological reasons for water scarcity, and how can we accurately predict future water availability? What is the potential for new or alternate sources of water (for example, desalinization plants, water harvesting techniques or undiscovered aquifers)? What are the demographic and health related problems tied to water scarcity?

Problem Statement The International Clean water Movement (ICM) wants your team to help them solve the world's water problems. Can you help improve access to clean, fresh water?

Task 1: Develop a model that provides a measure of the ability of a region to provide clean water to meet the needs of its population. You may need to consider the dynamic nature of the factors that affect both supply and demand in your modeling process.

Task 2: Using the UN water scarcity map (<http://www.unep.org/dewa/vitalwater/jpg/0222waterstress-overuse-EN.jpg>) pick one country or region where water is either heavily or moderately overloaded. Explain why and how water is scarce in that region. Make sure to explain both the social and environmental drivers by addressing physical and/or economic scarcity.

Task 3: In your chosen region from Task 2, use your model from Task 1 to show what the water situation will be in 15 years. How does this situation impact the lives of citizens of this region? Be sure to incorporate the environmental drivers' effects on the model components.

Task 4: For your chosen region, design an intervention plan taking all the drivers of water scarcity into account. Any intervention plan will inevitably impact the surrounding areas, as well

as the entire water ecosystem. Discuss this impact and the overall strengths and weaknesses of the plan in this larger context. How does your plan mitigate water scarcity?

Task 5: Use the intervention you designed in Task 4 and your model to project water availability into the future. Can your chosen region become less susceptible to water scarcity? Will water become a critical issue in the future? If so, when will this scarcity occur?

Task 6: Write a 20-page report (the one-page summary sheet does not count in the 20 pages) that explains your model, water scarcity in your region with no intervention, your intervention, and the effect of your intervention on your region's and the surrounding area's water availability. Be sure to detail the strengths and weaknesses of your model. The ICM will use your report to help with its mission to produce plans to provide access to clean water for all citizens of the world. Good luck in your modeling work!

Possible

Resources

An Overview of the State of the World's Fresh and Marine Waters. 2nd Edition, 2008. (<http://www.unep.org/dewa/vitalwater/index.html>).

The World's Water: Information on the World's Freshwater Resources.

(<http://worldwater.org>). AQUASTAT.

Food and Agriculture

Organization of the United Nations. FAO Water Resources.

(http://www.fao.org/nr/water/aquastat/water_res/index.stm).

The State of the World's Land and Water Resources for food and agriculture. 2011.

(<http://www.fao.org/docrep/017/i1688e/i1688e00.htm>).

GrowingBlue: Water. Economics. Life. (<http://growingblue.com>).

World Resources Institute. www.wri.org.

****Note that the 2013 Mathematical Competition in Modeling (Problem B) and the 2009 High School Modeling Competition in Modeling (Problem A) were related to modeling different aspects of water scarcity.**

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

ICM2016 问题-E 我们朝着干渴的星球迈进吗？

世界上清洁的水会耗尽吗？根据联合国的统计，有 1.6 亿人（占世界人口的四分之一）缺水。上个世纪，水的消耗速度是人口增速的两倍。人类对工业、农业和住宅用途都需要水资源。水资源短缺的原因主要有两种：物理短缺和经济短缺。物理短缺是指地区水量不足以满足需求。经济短缺是指地区有水，但管理不善和基础设施缺乏，限制了清洁水的可用性。许多科学家认为，随着气候变化和人口增长，缺水问题越来越恶化。用水以人口的两倍增加的事实表明，短缺还有其他的原因——可能是个人消费的速度增长，或是工业消耗增加，或是增加的污染消耗了清洁水的供应？或者是其他什么原因？

是否可以所有人提供清洁水？水的供应必须考虑物理可用性（如天然水资源，技术进步：如海水淡化厂或集雨技术等）。理解水的可用性本身是个跨学科问题。不仅要理解环境对供水的限制，而且要考虑社会因素如何影响清洁水的可用性和分配。例如，缺乏适当的卫生条件可以导致水质下降，人口增加也会增加一个区域内的供水负担。在分析水资源短缺的问题时，必须考虑以下类型的问题。人类历史上缺水是如何加剧或缓解的？缺水的地质、地形和生态原因是什么？我们如何准确预测未来水资源的可用性？潜在新的或备用水源是什么？（例如，海水淡化工厂，集雨技术或未被发现的地下蓄水层）？与缺水相关的人口统计学和健康问题是什么？

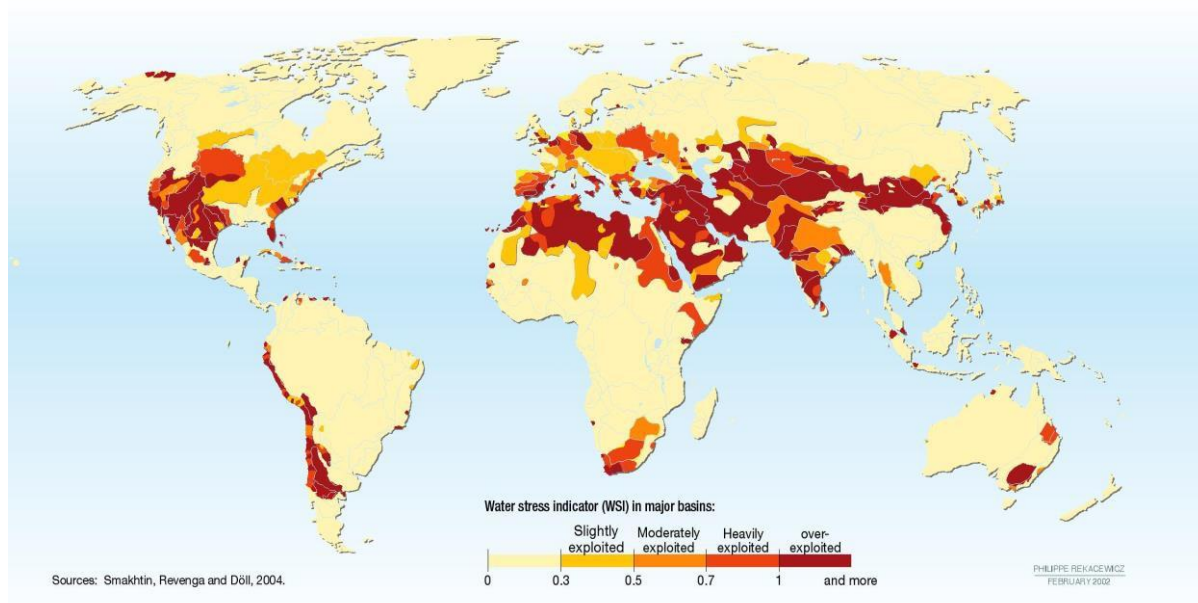
问题陈述：国际清洁水运动组织(ICM)希望您的团队来帮助他们解决世界水问题。你能帮助改善清洁、新鲜水的获取吗？

任务 1:

建立一个模型，该模型提供衡量一个地区为其人口提供清洁水的能力，在建模过程中，您可能需要考虑影响供给和需求的动态特性。

任务 2:

使用联合国缺水地图(



)选择一个严重缺水或中度缺水的国家或地区 解释该地区为什么以及如何缺水。一定要通过物理短缺或经济短缺两个方面，来解释社会和环境驱动因素。

任务 3:

在任务 2 中选择的地区，用任务 1 的模型展示未来 15 年的水状况。这种状况如何影响这个地区的公民的生活？一定要加入环境驱动因素对模型构件的作用。

任务 4:

根据你所选择的区域，设计一个考虑到所有缺水驱动因素的干预计划。任何干预计划将不可避免地影响周围地区和整个水生态系统。在更大的环境中，讨论这种影响和整体计划的优缺点。你的计划如何缓解缺水？

任务 5:

使用任务 4 设计的干预计划和你的模型，预测未来水资源的可用性。你选择的地区缺水会变得不太容易受缺水影响吗？水会成为未来关键议题吗？如果是这样，这种短缺什么时候会发生？

任务 6:

写一份 20 页的报告（1 页统计表不计算在 20 页内）来解释你的模型，所选地区没有干预计划时的缺水状况，你的干预计划，干预计划对所选地区和周边水资源可用性的作用。一定详细说明模型的优点和缺点。ICM 将使用你的报告来帮助其相关部门制定计划，为全世界所有公民提供清洁水。

祝你们建模顺利！

可能用到的资料：

(<http://www.unep.org/dewa/vitalwater/index.html>).世界淡水和海水状况概览，2008 第 2 版；(<http://worldwater.org>).世界上的水：世界淡水资源信息(http://www.fao.org/nr/water/aquastat/water_res/index.stm).联合国粮农组织，FAO 水资源(<http://www.fao.org/docrep/017/i1688e/i1688e00.htm>).粮食和农业用地和水状况(<http://growingblue.com>).水、经济和生活 www.wri.org.水资源机构。

注意，2013 年数学建模问题 B 和 2009 年高中生数学建模问题 A，是对缺水

问题不同方面的建模。

ICM 的解决方案应该包含一个 1 页的摘要，你的解决方案不能超过 20 页最多 21 页。注意：附录和参考文献不计入 20 页内。

ICM 2016 Problem F Modeling Refugee Immigration Policies

With hundreds of thousands of refugees moving across Europe and more arriving each day, considerable attention has been given to refugee integration policies and practices in many countries and regions. History has shown us that mass fleeing of populations occur as a result of major political and social unrest and warfare. These crises bring a set of unique challenges that must be managed carefully through effective policies. Events in the Middle East have caused a massive surge of refugees emigrating from the Middle East into safe haven countries in Europe and parts of Asia, often moving through the Mediterranean and into countries such as Turkey, Hungary, Germany, France, and UK. By the end of October 2015, European countries had received over 715,000 asylum applications from refugees. Hungary topped the charts with nearly

1,450 applications per 100,000 inhabitants, but with only a small percentage of those requests granted (32% in 2014), leaving close to a thousand refugees homeless per every 100K residents of the country. Europe has established a quota system where each country has agreed to take in a particular number of refugees, with the majority of the resettlement burden lying with France and Germany.

The refugees travel multiple routes – from the Middle East through (1) West Mediterranean, (2) Central Mediterranean, (3) Eastern Mediterranean, (4) West Balkans, (5) Eastern Borders, and (6) Albania to Greece (See these routes mapped out in <http://www.bbc.com/news/world-europe-34131911>). Each route has different levels of safety and accessibility, with the most popular route being Eastern Mediterranean and the most dangerous, Central Mediterranean. Countries that have been burdened the most are concerned about their capacity to provide resources for the refugees such as food, water, shelter, and healthcare. There are numerous factors that determine how the refugees decide to move through the region. Transportation availability, safety of routes and access to basic needs at destination are considered by each individual or family in this enormous migration.

The UN has asked your team, the ICM-RUN (RefUgee aNalytics) to help develop a better understanding of the factors involved with facilitating the movement of refugees from their countries of origin into safehaven countries.

Your Specific

Tasks:

1. Metrics of refugee crises. Determine the specific factors which can either enable or inhibit the safe and efficient movement of refugees. There are attributes of the individuals themselves, the routes they must take, the types of transportation, the countries' capacity, including number of entry points and resources available to refugee population. This first task requires

ICM-RUN to develop a set of measures and parameters and justify why they should be included in the analysis of this crisis.

2. Flow of refugees. Create a model of optimal refugee movement that would incorporate projected flows of refugees across the six travel routes mentioned in the problem, with consideration of transportation routes/accessibility, safety of route and countries' resource capacities. You can include different routes, different entry points, single or multiple entry points, and even different countries. Use the metrics that you established in Task 1 to determine the number of refugees, as well as the rate and point of entry necessary to accommodate their movement. Be sure to justify

any new elements you have added to the migration and explain the sensitivities of your model to these dynamics.

3. Dynamics of the crisis. Refugee conditions can change rapidly. Refugees seek basic necessities for themselves and their families in the midst of continuously changing political and cultural landscapes. In addition, the capacity to house, protect, and feed this moving population is dynamic in that the most desired destinations will reach maximum capacity the quickest, creating a cascade effect altering the parameters for the patterns of movement. Identify the environmental factors that change over time; and show how capacity can be incorporated into the model to account for these dynamic elements. What resources can be prepositioned and how should they be allocated in light of these dynamics? What resources need priority and how do you incorporate resource availability and flow in your model? Consider the role and resources of both government and non-government agencies (NGOs). How does the inclusion of NGO's change

your model and strategy? Also consider the inclusion of other refugee destinations such as Canada, China, and the United States. Does your model work for these regions as well?

4. Policy to support refugee model. Now that you have a working model, ICM-RUN has been asked to attend a policy strategy meeting where your team is asked to write a report on your model and propose a set of policies that will support the optimal set of conditions ensuring the optimal migration pattern. Your UN commission has asked you to consider and prioritize the health and safety of refugees and of the local populations. You can include as many parameters and considerations as you see fit to help to inform the strategic policy plan, keeping in mind the laws and cultural constraints of the effected countries. Consider also the role and actions of nongovernmental organizations (NGOs).

5. Exogenous events. In addition to endogenous systemic dynamics, exogenous events are also highly likely to occur and alter the situation parameters in these volatile environments, For example, a major terrorist attack in Paris, France has been linked to the Syrian refugee crisis, and has resulted in substantial shifts in the attitudes and policies of many European countries with respect to refugees. The event has also raised concerns among local populations. For example, Brussels, Belgium was placed in a lockdown after the Paris raids in attempts to capture possible terrorists. a) What parameters of the model would likely shift or change completely in a major exogenous event? b) What would be the cascading effects on the movement of refugees in neighboring countries? c) How will the immigration policies that you recommend be designed to be resilient to these types of events?

6. Scalability. Using your model, expand the crisis to a larger scale – by a factor of 10. Are there features of your model that are not scalable to larger populations? What parameters in

your model change or become irrelevant when the scope of the crisis increases dramatically? Do new parameters need to be added? How does this increase the time required to resolve refugee placement? If resolution of the refugee integration is significantly prolonged, what new issues might arise in maintaining the health and safety of the refugee and local populations? What is the threshold of time where these new considerations are in play? For example, what policies need to be in place to manage issues such as disease control, childbirth, and education?

The Report: The UN Commission on Refugees has asked your ICM-RUN team to provide them a 20page report that considers the factors given in your tasks. Each team should also write a 1 page policy recommendation letter which will be read by the UN Secretary General and the Chief of Migration.

Your ICM submission should consist of a 1 page Summary Sheet, a 1 page letter to the UN, and your solution (not to exceed 20 pages) for a maximum of 22 pages. Note: The appendix and references do not count toward the 22 page limit.

The Commission has also provided you with some on-line references that may be helpful:

<http://www.bbc.com/news/world-europe-34131911>

<http://www.iom.int/>

<http://iusp2009.princeton.edu/papers/9085>

4

<http://www.unhcr.org/pages/49c3646c4d6.h>

tml

http://www.nytimes.com/2015/08/28/world/migrants-refugees-europe-syria.html?_r=0

<http://www.who.int/features/qa/88/en/>

<http://www.euro.who.int/en/health-topics/health-determinants/migration-and-health/migrant-health-in-the-european-region/migration-and-health-key-issues>

<https://www.icrc.org/en/war-and-law/protected-persons/refugees-displaced-persons>

ICM2016 问题-F 难民移民政策模型

随着难民成千上万的移动在欧洲，每天多到达，相当多的关注已经给予难民融合的政策和做法在许多国家和地区。历史告诉我们，人口大规模逃离发生的重大政治和社会动荡和战争的结果。这些危机带来的一组必须谨慎地通过有效的政策来管理独特的挑战。在中东地区发生的事件引起了中东的移民进入避风港的国家在欧洲和亚洲部分地区的大批难民激增，往往通过地中海和成，如土耳其，匈牙利，德国，法国和英国的发展中国家转移。到 2015 年 10 月月底，欧洲各国已经从难民收到了超过 715000 庇护申请。匈牙利荣登排行榜，每 10 万居民近 1,450 所有课程，但仅授予那些请求的很小比例（2014 年为 32%），离开接近千难民每天每 10 万居民的国家无家可归。欧洲已经建立了每个国家都同意采取难民特定数量，与广大的安置负担躺在法国和德国的配额制度。难民旅行多条路线-从中东到（1）西地中海（2）地中海中部，（3）东地中海，（4）西巴尔干地区，（5）的东部边界，以及（6）阿尔巴尼亚希腊（见这些航线 <http://www.bbc.com/news/world-europe-34131911> 映射出）。每个航线都有不同程度的安全性和便利性，与最流行的路线是东地中海和最危险的，环地中海。已经背负了大多数国家担心自己的能力，为难民如食物，水，住所和医疗保健提供资源。有迹象表明，确定难民如何决定通过该区域移动诸多因素。运输可用性，路线和目的地获得基

本需求的安全性是由在这个巨大的迁移每一个人或家庭的考虑。

联合国已经问过你的团队，**ICM-RUN**（难民分析），以帮助更好地了解参与促进难民从他们的原籍国运动进入安全港计划的国家的因素。

您的任务：

1.对难民危机的衡量。确定特定的因素，可能有助于或约束难民的安全、高效流动。这有以下属性特征：难民自身，迁徙路线，交通运输，国家的能力（包括入口点数目和可提供的资源）。第一项任务需要制定一系列措施和参数来证明为什么分析危机时需要考虑这些条件。

2.难民的流动。建立一个最优的难民迁徙模型，模型要包括 6 条路线上预测的流动量，考虑以下几个方面：交通路线/可达性、路线安全性和国家的资源能力。您可以包括不同航线、不同入口点，单个或多个入口点，甚至不同国家。使用您在任务 1 建立的度量模型确定难民数量，以及满足难民迁徙所必要的入口点数和比率。务必能证明任何加入迁徙的新要素，同时解释这些动态变量的敏感性。

3.危机的动态。难民条件可能随时变化。难民在寻求生活必需品同时他们家庭处在不断变化的政治文化背景中。此外，目的国家的住所接待量、保护、食物等是动态变化并以最快速度增至最大，产生一系列影响导致修改迁徙模型的参数。确定随时间变化的环境因素；同时说明有多大容量能被融入模型来解释这些动态变量。如何根据这些动态变化因素预先放置哪些物资？优先放置哪些物资以及如何模型中加入物资的实用性和流通性？考虑政府和非政府机构各自的资源和任务。非政府机构的行动如何改变你的模型和策略？同时考虑难民的其他可能目的地的相关内容，如加拿大、中国、和美国。您的模型在这些地区能否也起作用？

4.难民模型的政策。基于上述模型发表报告，提出一系列政策将有助于创造最优条件确保最优迁徙模型。你需要安排好难民和当地居民的健康安全等事项。您可以尽可能多的囊括你认为适合推动政策制定的参数和因素，同时牢记受影响国家的法律和文化的约束。还要考虑非政府机构的任务和行动。

5.外源性事件。除了内源性的系统动力学，外源性事件也是极有可能发生，改变不稳定的环境中的环境参数，例如，在法国巴黎的重大恐怖袭击与叙利亚避难危机联系在一起，导致之前尊重难民的许多欧洲国家在态度和政策方面发生实质性的转变。事件也引起了当地民众的关注。例如，布鲁塞尔，锁定的巴黎袭击在捕捉的恐怖分子藏在比利时。

a)在一件重要的外源性事件中模型的哪些参数会发生变化或者完全性变化？

b)邻国的难民事件会造成哪些连锁反应？

c)你建议的移民政策将如何适应种种此类事件？

6.可扩展性。使用您的模型，将危机扩大到更大的规模——10 倍。模型中有不可扩展到人口模型的功能吗？当这场危机的范围大大增加，你的模型中哪些参数发生变化或者变成无关变量？如何增加解决难民安置所需的时间？如果难民融合措施的实施显著拖延，为了维持难民和当地居民的安全与健康会出现哪些新的问题？这些新的想法起作用的时间阈值是在什么时候？例如，为了管控好疾病、生育、教育等问题需要哪些政策做到位？

MCM 2017 Problem 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.

MCM2017 问题- A 管理赞比西河

赞比西河上的卡里巴水坝是非洲较大的水坝之一。它的建设是有争议的，南非风险管理研究所的 2015 年报告包括一个警告-大坝是急需维护。赞比西河管理局（ZRA）可提供若干选择，以解决这一问题。ZRA 特别感兴趣的有三个选项：

选项 1 修复现有的 Kariba 水坝

选项 2 重建现有的 Kariba 水坝

选项 3 拆除 Kariba 水坝，并更换为沿赞比西河的一系列十到二十个较小的水坝。这个问题有两个主要要求：

要求 1 ZRA 管理要求对所列出的三个选项进行简要评估，并提供足够的详细信息，以

提供与每个选项相关的潜在成本和收益的概述。此要求的长度不应超过两页，除了主要报告之外，还必须提供此页面。

要求 2 对选项 (3) 进行详细分析 - 删除 Kariba 水坝，并用赞比西河沿岸一系列十至二十个较小的水坝替代。这个新的水坝系统应该与现有的 Kariba 水坝具有相同的整体水管理能力，同时为现有的水坝提供与卡里巴湖相同或更高水平的保护和水管理选择。您的分析必须支持关于沿赞比西河新坝的数量和位置的建议。在您的要求 2 报告中，您应该包括一个策略，用于调节通过您的新多坝系统的水流，从而在安全和成本之间提供合理的平衡。除了解决已知或预测的正常水循环，您的战略应为 ZRA 经理提供指导，解释和证明应当采取的行动，以正确处理应急水流情况（即洪水和/或长期低水位状况）。您的策略应为从最大预期排放到最小预期排放的极端水流提供具体指导。最后，您的建议战略应包括解决对赞比西河不同地区暴露于极端条件最有害影响的位置和时间长度的任何限制的信息。

MCM 2017 Problem B: Merge After Toll

Multi-lane divided limited-access toll highways use “ramp tolls” and “barrier tolls” to collect tolls from motorists. A ramp toll is a collection mechanism at an entrance or exit ramp to the highway and these do not concern us here. A barrier toll is a row of tollbooths placed across the highway, perpendicular to the direction of traffic flow. There are usually (always) more tollbooths than there are incoming lanes of traffic (see former 2005 MCM Problem B). So when exiting the tollbooths in a barrier toll, vehicles must “fan in” from the larger number of tollbooth egress lanes to the smaller number of regular travel lanes. A toll plaza is the area of the highway needed to facilitate the barrier toll, consisting of the fan-out area before the barrier toll, the toll barrier itself, and the fan-in area after the toll barrier. For example, a three-lane highway (one direction) may use 8 tollbooths in a barrier toll. After paying toll, the vehicles continue on their journey on a highway having the same number of lanes as had entered the toll plaza (three, in this example).

Consider a toll highway having L lanes of travel in each direction and a barrier toll containing B tollbooths ($B > L$) in each direction. Determine the shape, size, and merging pattern of the area following the toll barrier in which vehicles fan in from B tollbooth egress lanes down to L lanes of traffic. Important considerations to incorporate in your model include accident prevention, throughput (number of vehicles per hour passing the point where the end of the plaza joins the L outgoing traffic lanes), and cost (land and road construction are expensive). In particular, this problem does not ask for merely a performance analysis of any particular toll plaza design that may already be implemented. The point is to determine if there are better solutions (shape, size, and merging pattern) than any in common use.

Determine the performance of your solution in light and heavy traffic. How does your solution change as more autonomous (self-driving) vehicles are added to the traffic mix? How is your solution affected by the proportions of conventional (human-staffed) tollbooths, exact-change (automated) tollbooths, and electronic toll collection booths (such as electronic toll collection via a transponder in the vehicle)?

Your MCM submission should consist of a 1 page Summary Sheet, a 1-2 page letter to the New Jersey Turnpike Authority, and your solution (not to exceed 20 pages) for a maximum of 23 pages.

Note: The appendix and references do not count toward the 23 page limit.

MCM2017 问题- B 高速路的收费站

高速路的收费站会通过“匝道收费”和“过卡收费”两种方式收取驾驶员的高速费。匝道收费是一种在入口和出口的回道处设立的收费站，但是今天这个不在我们的讨论范围之列。过卡收费是一排垂直高速路行驶方向设立的许多收费窗口。而这些收费窗口通常都会比车道条数要多(详情参见 2005 年 MCM 的 B 题)。因此，当汽车驶出收费站之后，车流必须从较宽的收费站出口呈扇形快速并入车道较少的常规机动车道。收费广场是为改善过卡之后的拥堵状况建立的，包括收费站之前多车道区域，收费站本身以及经过收费站之后的扇入区域。举个例子，一条单向的三车道高速路需要 8 个收费窗口，在支付过桥费后，驾驶员可以继续保持与自己进收费广场之前的相同数量的车道(在该示例中为三个)的高速公路上继续行驶。

试考虑一个收费高速公路上两个方向都有 L 条车道，每个方向上有 B 个收费站($B > L$)，请确定你设计的收费区域的形状，大小以及当汽车从驶出 B 时如何将车道进行合并至 L 条车道。

在你的设计中请注明一些重要事项如事故预防，吞吐量(即每小时有多少车辆从收费广场驶出，驶入 L 条车道。)成本(土地和公路建设的费用很昂贵)，重点在于并非只是对现有的收费广场进行性能分析，请试着探索是否有比现今采用的更好的收费解决方案(包括形状，大小以及收费方式)。

请确定你的解决方案在小车流量和大车流量下的性能表现。随着更多的私家(自驾)车进入其中，你的解决方案会有什么改变呢？你的解决方案会如何影响常规收费站(需要人员进行收费)，不找零(自动化的)收费站以及电子收费站的(比如通过车内的发射器应答器来收取费用)？

您的 MCM 提交应包括 1 页摘要表，1-2 页给新泽西州收费公路管理局的信件，以及您的解决方案(不超过 20 页)，最多 23 页。注意：附录和参考文献不计入 23 页的限制。

MCM 2017 Problem C: “Cooperate and navigate”

Traffic capacity is limited in many regions of the United States due to the number of lanes of roads. For example, in the Greater Seattle area drivers experience long delays during peak traffic hours because the volume of traffic exceeds the designed capacity of the road networks. This is particularly pronounced on Interstates 5, 90, and 405, as well as State Route 520, the roads of particular interest for this problem.

Self-driving, cooperating cars have been proposed as a solution to increase capacity of highways without increasing number of lanes or roads. The behavior of these cars interacting with the existing traffic flow and each other is not well understood at this point.

The Governor of the state of Washington has asked for analysis of the effects of allowing self-driving, cooperating cars on the roads listed above in Thurston, Pierce, King, and Snohomish counties. (See the provided map and Excel spreadsheet). In particular, how do the effects change

as the percentage of self-driving cars increases from 10% to 50% to 90%? Do equilibria exist? Is there a tipping point where performance changes markedly? Under what conditions, if any, should lanes be dedicated to these cars? Does your analysis of your model suggest any other policy changes?

Your answer should include a model of the effects on traffic flow of the number of lanes, peak and/or average traffic volume, and percentage of vehicles using self-driving, cooperating systems. Your model should address cooperation between self-driving cars as well as the interaction between self-driving and non-self-driving vehicles. Your model should then be applied to the data for the roads of interest, provided in the attached Excel spreadsheet.

Some useful background information:

- On average, 8% of the daily traffic volume occurs during peak travel hours.
- The nominal speed limit for all these roads is 60 miles per hour.
- Mileposts are numbered from south to north, and west to east.
- Lane widths are the standard 12 feet.
- Highway 90 is classified as a state route until it intersects Interstate 5.
- In case of any conflict between the data provided in this problem and any other source, use the data provided in this problem.

Definitions:

milepost: A marker on the road that measures distance in miles from either the start of the route or a state boundary.

average daily traffic: The average number of cars per day driving on the road.

interstate: A limited access highway, part of a national system.

state route: A state highway that may or may not be limited access.

route ID: The number of the highway.

increasing direction: Northbound for N-S roads, Eastbound for E-W roads.

decreasing direction: Southbound for N-S roads, Westbound for E-W roads.

MCM2017 问题- C “合作和导航”

美国许多地区由于道路的数量限制，交通容量有限。例如，在大西雅图地区，由于交通量超过道路网络的设计容量，司机在交通高峰时段经历长时间的延误。这在 5 号，90 号和 405 号州际公路以及 520 号国道在这个问题上显得尤为明显。

自动驾驶车已经作为增加公路能力而不用拓宽车道的方案提出，但是在这一点上，人们并未很好的理解自动驾驶车与现有交通工具的关系。

华盛顿州州长要求就自动驾驶车对于 Thurston, Pierce 和 Snohomish 等地交通的影响。(详情请参见提供的地图和 Excel 表格)。重点是当这种自动驾驶车的数量占比从 10% 增加到 50% 后，效果会有什么变化？到 90% 呢？其中是否存在均衡点？是否有明显的变化临界点？假设条件满足，是否应该为这些车设立专用车道？你的模型分析是否提出了改善政策的建议？

你需要构建一个模型，包括对车道流量，峰值、（和/或）平均交通量，以及自动驾驶车所占的比例的协作系统。你的模型分析应该含有对自动驾驶车和非自动驾驶车之间的关系分析。你的模型分析应该满足附件中 Excel 提供的指定道路数据。

你的 MCM 文件应该包括：1 页摘要表，1-2 页的州长回信，以及你的解决方案（不超过

20 页), 整份文件最多 23 页, 注:附录和参考文献不计入 23 页的限制当中。

ICM 2017 Problem D: Optimizing the Passenger Throughput at an Airport Security Checkpoint

Following the terrorist attacks in the US on September 11, 2001, airport security has been significantly enhanced throughout the world. Airports have security checkpoints, where passengers and their baggage are screened for explosives and other dangerous items. The goals of these security measures are to prevent passengers from hijacking or destroying aircraft and to keep all passengers safe during their travel. However, airlines have a vested interest in maintaining a positive flying experience for passengers by minimizing the time they spend waiting in line at a security checkpoint and waiting for their flight. Therefore, there is a tension between desires to maximize security while minimizing inconvenience to passengers.

During 2016, the U.S. Transportation Security Agency (TSA) came under sharp criticism for extremely long lines, in particular at Chicago's O'Hare international airport. Following this public attention, the TSA invested in several modifications to their checkpoint equipment and procedures and increased staffing in the more highly congested airports. While these modifications were somewhat successful in reducing waiting times, it is unclear how much cost the TSA incurred to implement the new measures and increase staffing. In addition to the issues at O'Hare, there have also been incidents of unexplained and unpredicted long lines at other airports, including airports that normally have short wait times. This high variance in checkpoint lines can be extremely costly to passengers as they decide between arriving unnecessarily early or potentially missing their scheduled flight. Numerous news articles, including [1,2,3,4,5], describe some of the issues associated with airport security checkpoints.

Your Internal Control Management (ICM) team has been contracted by the TSA to review airport security checkpoints and staffing to identify potential bottlenecks that disrupt passenger throughput. They are especially interested in creative solutions that both increase checkpoint throughput and reduce variance in wait time, all while maintaining the same standards of safety and security.

The current process for a US airport security checkpoint is displayed in Figure 1.

Zone A:

➤ Passengers randomly arrive at the checkpoint and wait in a queue until a security officer can inspect their identification and boarding documents.

Zone B:

➤ The passengers then move to a subsequent queue for an open screening line; depending on the anticipated activity level at the airport, more or less lines may be open.

➤ Once the passengers reach the front of this queue, they prepare all of their belongings for X-ray screening. Passengers must remove shoes, belts, jackets, metal objects, electronics, and containers with liquids, placing them in a bin to be X-rayed separately; laptops

and some medical equipment also need to be removed from their bags and placed in a separate bin.

All of their belongings, including the bins containing the aforementioned items, are moved by conveyor belt through an X-ray machine, where some items are flagged for additional search or screening by a security officer (Zone D).

Meanwhile the passengers process through either a millimeter wave scanner or metal detector.

Passengers that fail this step receive a pat-down inspection by a security officer (Zone D).

Zone C:

The passengers then proceed to the conveyor belt on the other side of the X-ray scanner to collect their belongings and depart the checkpoint area.

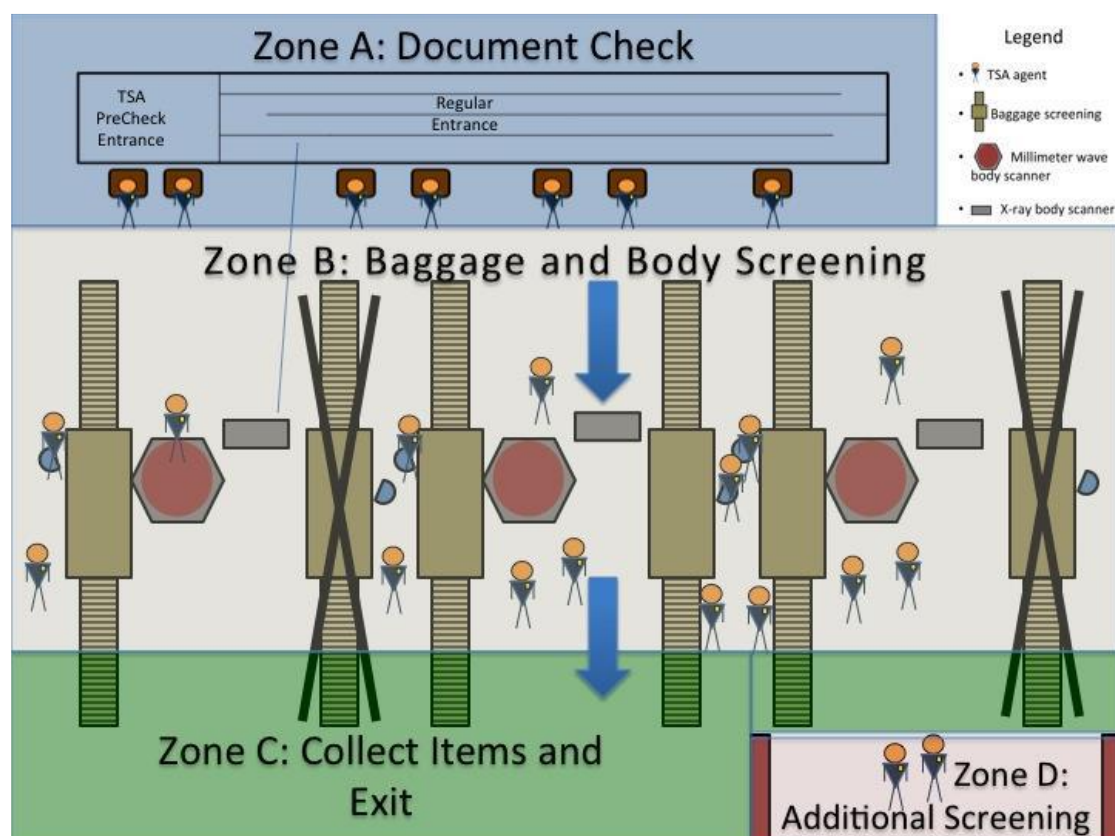


Figure 1: Illustration of the TSA Security Screening Process.

Approximately 45% of passengers enroll in a program called Pre-Check for trusted travelers. These passengers pay \$85 to receive a background check and enjoy a separate screening process for five years. There is often one Pre-Check lane open for every three regular lanes, despite the fact that more passengers use the Pre-Check process. Pre-Check passengers and their bags go through the same screening process with a few modifications designed to expedite screening. Pre-Check passengers must still remove metal and electronic items for scanning as well as any liquids, but are not required to remove shoes, belts, or light jackets; they also do not need to remove their computers from their bags.

Data has been collected about how passengers proceed through each step of the security screening process. [Click here to view the Excel data.](#)

Your specific tasks are:

a. Develop one or more model(s) that allow(s) you to explore the flow of passengers through a security check point and identify bottlenecks. Clearly identify where problem areas exist in the current process.

b. Develop two or more potential modifications to the current process to improve passenger throughput and reduce variance in wait time. Model these changes to demonstrate how your modifications impact the process.

c. It is well known that different parts of the world have their own cultural norms that shape the local rules of social interaction. Consider how these cultural norms might impact your model. For example, Americans are known for deeply respecting and prioritizing the personal space of others, and there is a social stigma against “cutting” in front of others. Meanwhile, the Swiss are known for their emphasis on collective efficiency, and the Chinese are known for prioritizing individual efficiency. Consider how cultural differences may impact the way in which passenger’s process through checkpoints as a sensitivity analysis. The cultural differences you apply to your sensitivity analysis can be based on real cultural differences, or you can simulate different traveler styles that are not associated with any particular culture (e.g., a slower traveler). How can the security system accommodate these differences in a manner that expedites passenger throughput and reduces variance?

d. Propose policy and procedural recommendations for the security managers based on your model. These policies may be globally applicable, or may be tailored for specific cultures and/or traveler types.

In addition to developing and implementing your model(s) to address this problem, your team should validate your model(s), assess strengths and weaknesses, and propose ideas for improvement (future work).

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

References:

[1] <http://www.wsj.com/articles/why-tsa-security-lines-arent-as-bad-as-you-d-feared-1469032116>

[2] <http://www.chicagotribune.com/news/ct-tsa-airport-security-lines-met-20160823-story.html>

[3] <http://www.cnn.com/2016/06/09/travel/tsa-security-line-wait-times-how-long/>

[4]

<http://wgntv.com/2016/07/13/extremely-long-lines-reported-at-chicago-midway-airports-tsa-check-point/>

[5]

<http://www.cnbc.com/2016/04/14/long-lines-and-missed-flights-fuel-criticism-of-tsa-screening.html>

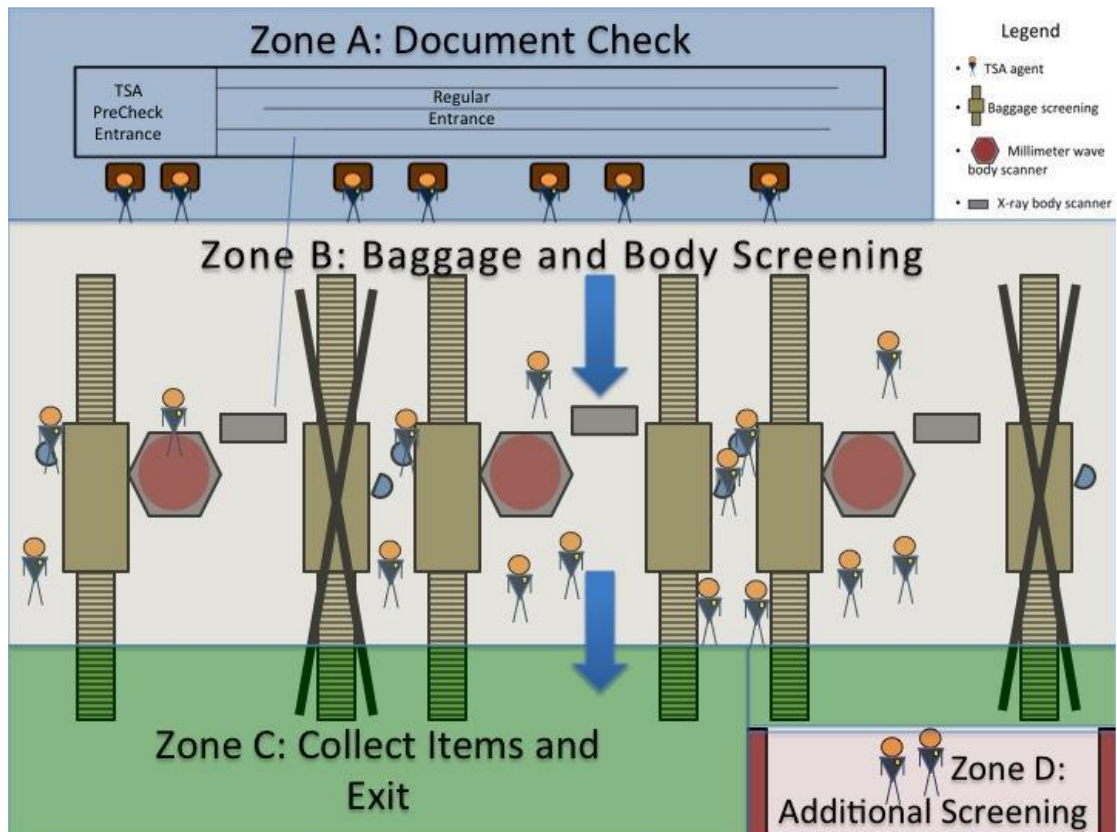
ICM2017 问题- D：在机场安全检查站优化乘客吞吐量

继 2001 年 9 月 11 日美国发生恐怖袭击事件后，全世界的机场安全状况得到显著改善。

机场有安全检查站,在那里,乘客及其行李被检查爆炸物和其他危险物品。这些安全措施的目的是防止乘客劫持或摧毁飞机,并在旅行期间保持所有乘客的安全。然而,航空公司有既得利益,通过最小化他们在安全检查站排队等候并等待他们的航班的时间,为乘客保持积极的飞行体验。因此,在希望之间存在最大化安全性同时最小化对乘客的不便的张力。

在 2016 年,美国运输安全局(TSA)受到了对极长线路,特别是在芝加哥的奥黑尔国际机场的尖锐批评。在此公众关注之后,TSA 投资对其检查点设备和程序进行了若干修改,并增加了在高度拥堵的机场中的人员配置。虽然这些修改在减少等待时间方面有一定的成功,但 TSA 在实施新措施和增加人员配置方面花费了多少成本尚不清楚。除了在 O'Hare 的问题,还有在其他机场,包括通常有短的等待时间的机场不明原因和不可预测的长线的事件。检查站线路的这种高差异对于乘客来说可能是极其耗时的,因为他们决定要尽早到达,因为可能延迟错过他们的预定航班之间。许多新闻文章,包括[1,2,3,4,5],描述了与机场安全检查站相关的一些问题。

您的内部控制管理(ICM)团队已经与 TSA 签订合同,审查机场安全检查站和人员配置,以确定可能干扰乘客吞吐量的瓶颈。他们特别感兴趣的创意解决方案,既增加检查点吞吐量,减少等待时间的方差,同时保持相同的安全和安全标准。



美国机场安全检查点的当前流程如图 1 所示。

区域 A:

乘客随机到达检查站,并等待队列,直到安全人员可以检查他们的身份证明和登机文件。

区域 B:

然后乘客移动到打开的筛选线的后续队列;根据机场的预期活动水平,或多或少的线路可能开放。

一旦乘客到达这个队列的前面,他们准备所有的物品用于 X 射线检查。乘客必须用液体去除鞋子,皮带,夹克,金属物体,电子产品和容器,将它们放置在单独的 X 射线箱中;笔记本电脑和一些医疗设备也需要从其袋中取出并放置在单独的容器中。

他们的所有物品，包括包含上述物品的箱子，由传送带通过 X 光机移动，其中一些物品被标记，供安全人员（D 区）进行额外的搜索或筛选。

同时乘客通过毫米波扫描仪或金属探测器进行处理。

未能通过此步骤的乘客接受安全官员（D 区）的轻击检查。

C 区：

乘客然后前进到 X 射线扫描仪另一侧的传送带，收集他们的物品并离开检查站区域。

图 1：TSA 安全筛选过程的图示。

大约 45% 的乘客报名参加一个称为预检查信任旅行者的计划。这些乘客支付 85 美元，接受背景调查，并享受五年的独立筛选程序。尽管事实上更多的乘客使用预检查过程，但是每三条常规车道通常有一个预检查车道打开。预检查乘客和他们的行李经过相同的筛选过程，经过一些修改，以加快筛选。预检查乘客还必须移除扫描用的金属和电子物品以及任何液体，但不需要去除鞋子，皮带或灯罩；他们也不需要从他们的包里删除他们的电脑。收集了关于乘客如何进行安全检查过程的每个步骤的数据。

您的特定任务是：

- a. 开发一个或多个模型，允许您通过安全检查点探索乘客流，并识别瓶颈。清楚地确定当前流程中存在哪些问题区域。
- b. 对当前流程开发两个或多个潜在修改，以提高旅客吞吐量并减少等待时间的差异。对这些更改进行建模，以演示修改如何影响流程。
- c. 众所周知，世界上不同的地方都有自己的文化规范，塑造了地方社会互动的规则。考虑这些文化规范如何影响你的模型。例如，美国人以深为尊重和优先考虑别人的个人空间而闻名，在别人的面前“切割，或者理解为剪切”当作是一种社会歧视。同时，瑞士人以集体效率为重点，中国人以优先个人效率而闻名。考虑文化差异如何影响乘客的过程通过检查点作为敏感性分析的方式。您应用于敏感性分析的文化差异可以基于真实的文化差异，或者您可以模拟与任何特定文化（例如，较慢的旅行者）无关的不同旅行者风格。安全系统如何以加快乘客吞吐量并减少差异的方式来适应这些差异？
- d. 根据您的模型为安全管理器提出政策和程序建议。这些策略可以是全球适用的，或者可以针对特定文化和/或旅行者类型来定制。

除了开发和实施您的模型来解决这个问题，您的团队还应该验证您的模型，评估优势和弱点，并提出改进建议（未来工作）。

ICM 2017 Problem E: Sustainable Cities Needed!

Background:

Many communities are implementing smart growth initiatives in an effort to consider long range, sustainable planning goals. “Smart growth is about helping every town and city become a more economically prosperous, socially equitable, and environmentally sustainable place to live.”[2] Smart growth focuses on building cities that embrace the E’s of sustainability—Economically prosperous, socially Equitable, and Environmentally Sustainable. This task is more important than ever because the world is rapidly urbanizing. It is projected that by 2050, 66 percent of the world’s population will be urban—this will result in a projected 2.5 billion people being added to the urban population.[3] Consequently, urban planning has become increasingly important and

necessary to ensure that people have access to equitable and sustainable homes, resources and jobs.

Smart growth is an urban planning theory that originated in 1990's as a means to curb continued urban sprawl and reduce the loss of farmland surrounding urban centers. The ten principles for smart growth are[4]

- 1 Mix land uses
- 2 Take advantage of compact building design
- 3 Create a range of housing opportunities and choices
- 4 Create walkable neighborhoods
- 5 Foster distinctive, attractive communities with a strong sense of place
- 6 Preserve open space, farmland, natural beauty, and critical environmental areas
- 7 Strengthen and direct development towards existing communities
- 8 Provide a variety of transportation choices
- 9 Make development decisions predictable, fair, and cost effective
- 10 Encourage community and stakeholder collaboration in development decisions

These broad principles must be tailored to a community's unique needs to be effective. Thus, any measure of success must incorporate the demographics, growth needs, and geographical conditions of a city as well as the goal to adhere to the three E's.

Tasks:

The International City Management Group (ICM) needs your help implementing smart growth theories into city design around the world. Select two mid-sized cities (any city with a population of between 100,000 and 500,000 persons), on two different continents.

1. Define a metric to measure the success of smart growth of a city. It should consider the three E's of sustainability and/or the 10 principles of smart growth.
2. Research the current growth plan of the selected cities. Measure and discuss how the current growth plan of each city meets the smart growth principles. How successful are the current plans according to your metric?
3. Using smart growth principles develop a growth plan for both cities over the next few decades. Support why you chose the components and initiatives of your plans based on the geography, expected growth rates, and economic opportunities of your cities. Use your metric to evaluate the success of your smart growth plans.
4. Also using your metric, rank the individual initiatives within your redesigned smart growth plan as the most potential to the least potential. Compare and contrast the initiatives and their ranking between the two cities.
5. Suppose the population of each city will increase by an additional 50% by 2050, explain in what way(s) your plan supports this level of growth?

Your ICM submission should consist of a 1 page Summary Sheet and your solution cannot exceed 20 pages for a maximum of 21 pages. Note: The appendix and references do not count toward the 20 page limit.

References:

- [1] Smart Growth: Improving lives by improving communities. <https://smartgrowthamerica.org/>
 [2] EPA, "This is Smart Growth." 2016
<https://www.epa.gov/smartgrowth/smart-growth-publication>
 [3] World Urbanization Prospects. United Nations. 2014. <https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>

- [4] EPA, “Smart Growth: A Guide to Developing and Implementing Greenhouse Gas Reductions Programs.” 2011.
http://www.sustainablecitiesinstitute.org/Documents/SCI/Report_Guide/Guide_EPA_SmartGrowthGHGReduction_2011.pdf
- [5] Duany, Andres, Jeff Speck and Mike Lydon. The Smart Growth Manual. McGraw-Hill. 2010.

ICM2017 问题- E：需要可持续城市！

背景：

为了考虑和达到长期的可持续稳定发展的规划目标，许多社区正在实施智能化的初步增长计划。“智能化的增长会帮助每一个小镇和城市的经济变得更加繁荣，社会更加平等，变成从环境上来说更加适合可持续性稳定发展的居住地”。[2] 智能化增长侧重于城市建设，尤其注重可持续发展的经济体：经济繁荣，社会平等，和环境可持续性。对于现在来说，这个任务比以往都重要，因为这个世界正在迅速地城市化。预计到 2050 年，城市人口将达到世界总人口的 66%，也就是说这将导致 25 亿人口会加入世界城市人口。[3] 因此城市建设变得越来越重要和必要，以确保人们有社会平等和持续性发展的家园，资源，和工作机会。

智能化增长是一种起源于上个世纪 90 年代的城市规划理论。它的目标是遏制城市的持续蔓延以及以城市为中心的周边农田的流失和减少。智能化增长的十大原则是[4]

- . 1 混合搭配土地的用途
- . 2 最大化利用紧凑的建筑设计
- . 3 创造更多的住房机会和选择
- . 4 创造步行街道
- . 5 培养独特，有吸引力，和具有强烈当地地方感的社区
- . 6 保留开放空间，农田，自然景观，以及关键的环境地带
- . 7 加强和领导对于现有社区的发展
- . 8 提供多种交通工具的选择
- . 9 使得开发决策的结果可预测，公平，具有较高性价比
- . 10 鼓励社区和获利者在开发决策中的合作

这些广义的原则必须适应和满足每一个社区的特殊需求才会变得有效。因此，任何成功的衡量标准都必须包括一个城市的人口统计，增长需求和地理条件，以及严格遵守三个 E 的目标。

任务：

国际城市管理集团(ICM)需要你帮助他们实施智能化增长理论到世界各地的城市建设。选择两个在不同洲的中型城市（人口在 10 万到 50 万的任何城市）。

1. 定义一个可以衡量城市智能化增长成功率的指标。请考虑并且结合到可持续性发展的三个 E 和、或智能化增长的是个原则。
2. 研究所选择城市的当前发展计划。衡量并讨论所选择城市当前的增长计划是如何遵从智能化增长的原则的。根据你的指标，分析一下当前的计划是否成功，成功的程度如何。
3. 使用智能化增长的原则为两个城市做一个在未来几十年里的增长计划。说明与解释你是如何根据城市的地理位置，预期增长率和经济机会来安排你的增长计划的。使用你以上的指标来评定一下这个增长计划的成功率。

4. 使用你的指标, 把你重新设计的智能化增长计划中的每项计划从最具潜力到最不具潜力排一个名次。比较和对比这些和两个城市之间排名的关系。
5. 假设每个城市的人口在 2050 年会增长 50%, 解释一下你的计划会以什么样的方式来支持这种规模的成长。

您的 ICM 提交应包含 1 页的摘要表, 您的解决方案不能超过 20 页, 最多 21 页。注意: 附录和参考文献不计入 20 页的限制。

ICM 2017 PROBLEM F: Migration to Mars: Utopian Workforce of the 2100 Urban Society

The international agency, Laboratory of Interstellar Financial & Exploration Policy (LIFE), has recently (in this year of 2095) completed a series of short-term planned living experiments on our neighbor planet, Mars. New technologies, including personalized artificial augmentations units, will soon enable humans to inhabit manufactured cities on Mars by 2100. The first wave of migration, called Population Zero, will include 10,000 people.

The LIFE agency launched project UTOPIA: 2100, with the goal of creating an optimal workforce for the 22nd century to give all people the greatest quality of life with a vision of sustainability for the next 100 years. Over the last 20 years, several planned communities have been designed and built across Earth that tested several planned living conditions. These communities are driven by egalitarian principles in economics, government, workforce, and justice systems.

LIFE is seeking a set of mathematical and computational models that will inform the International Coalition on Mars (ICM) government on how to design an economic-workforce-education system that they can implement with Population Zero. In order to decide what procedure to follow, LIFE has hired the most qualified policy makers and data scientists with the goal to develop a set of policies to realize the migration to Mars. Your three-person policy modeling team is part of the group of advisors and policy makers. ICM has asked your group for a policy model and report that will result in a set of policy recommendations that will create a sustainable life-plan and will make the living experience on Mars in the year 2100 even better than the Earthly one in the current year of 2095.

New tools in network science, systems science, complex systems, organizational & industrial psychology, and other interdisciplinary fields provide new insights for understanding social and governmental systems, with important capabilities to deal with issues of scalability (relevant for both small and large populations and effects), modality (multiple layers), and dynamics (changes over time).

Population Zero aims to have optimal conditions in many workforce and social living factors (note that another team is being tasked with health policy, so ICM has asked that you exclude health care from your analysis). The mission of Population Zero is to create a sustainable society by maximizing both economic output (GDP) and happiness in the work place for its citizens. Of course, these two goals can be in opposition, so the policy recommendation has to consider balancing factors, such as:

- Income: Ensure adequate compensation so that all people can afford fundamental necessities (shelter, food, clothes).
- Education: Provide high quality education that prepares citizens for the needs and challenges of the 22nd Century.
- Equality: Improve the retention of women in the workforce, particularly in fields where they have been underrepresented or discriminated against on Earth.

Your ICM-directed tasks are:

1. Define parameters and specific outcomes related to the three priority factors (income, education, and social equality) in Population Zero. Some issues to consider are: a) minimum wage and salary distribution (income); b) skills required for an efficient workforce; types of governance and infrastructure needed to obtain these skills (education); and c) maternity and paternity leave, affordable childcare to ensure people can remain in the workforce (social equality).

a. Identify and define the specific outcomes that would indicate positive results across the three factors for the next decade (years 2100–2110). Consider what the goal is for each of these factors; for example, is the objective to improve the quality of living for all citizens or improve quantity of output of the system.

b. What are the major features of the population (eg. demographics, population size, and working conditions) that would contribute to these outcomes?

c. Create metrics that you will use to evaluate whether the system is meeting its objective by identifying and defining the critical parameters for each of the three factors.

2. You have been asked to generate a sample population of 10,000 people to emigrate to Mars. Extract data from a census dataset (link to one is provided below) or synthesize one.

a. From your data set, identify and analyze the demographic characteristics of this simulation of Population Zero. Analyze and describe demographic distributions, such as gender, ethnicity, age, and education levels.

b. Consider the distribution of citizens in terms of factors that will also help to meet goals of UTOPIA: 2100 – to build a peaceful, cooperative, egalitarian society. Are your data sufficient to determine these factors? For example, should the distribution of innovators versus producers be considered? Of skilled versus unskilled labor? Of families versus single people?

Link to PUMS data (if you desire to use this census data):

- PUMS data can be found via following links:

<http://www.census.gov/programs-surveys/acs/technical-documentation/pums.html>

<http://www2.census.gov/programs-surveys/acs/data/pums/2015/1-Year/>

- These links show how to extract the data in R:

<https://stat.ethz.ch/R-manual/R-devel/library/base/html/sample.html>

<https://cran.r-project.org/web/packages/sampling/sampling.pdf>

- This link show how to extract the data in MATLAB:

<https://www.mathworks.com/help/stats/datasample.html?requestedDomain=www.mathworks.com>

3. Build a model that includes the three identified factors (income, education, & social equality). Using the parameters that you created in task 1, define the key elements of a successful society for the next 10 years. When integrating these three factors, what are the critical interdependencies among the parameters? Are there additional constraints required to preserve the outcomes over the 10 year period? How often should the model be evaluated to ensure the goals of UTOPIA 2100 continue to be met? What might be economic, social, cultural, and other global factors that might

affect the viability of the model over that period? Based on these factors and constraints, answer the following:

a. Determine the optimal minimum wage and salary distribution to best manage the tension between wellbeing (higher quality of life) and support for those less equipped to provide labor services.

b. Identify terms in your model that can be most improved through contribution of new ideas. Describe the incentives to motivate contribution of those new ideas.

c. What is the best childcare and paternity/maternity leave strategies?

4. Now that you have created models for the three factors, proceed to merge these models into a global model. In task 3, you designed a model to provide optimal outcomes for society, at large. Now, consider how the model will function for different groups?

a. Identify the major subgroups of your workforce, and identify their main priorities. For example, unskilled labor force might be concerned with work hours, disability care, child care, and minimum wage, while the priorities of the professional workforce may be time off, training, and parental leave. Your model will dictate which subgroups you consider. You might have to develop new parameters to adequately evaluate each groups' priorities.

b. With the understanding that each group will have a different set of needs, perspectives, and criteria for success, analyze how closely their needs are met in terms of income, education, and equality. For example, does your model function differently across educational levels? Different ages? Different cultural values? Does your model function better for women or men? How are families affected?

c. With the consideration of the subgroups that you have identified, your previous model may no longer produce optimal outcomes. Adjust the model by adding new constraints or parameters to optimize the needs of the different subgroups. The goal is to maximize the priority outcomes of the subgroups without significantly reducing the global outcomes.

5. LIFE has planned additional migration phased over the next 100-years.

a. How sensitive is your model to the population selection for various migration phases? Does the demographic distribution of this population significantly change the outcomes? How does your sampling procedure affect your model? If migration and growth in future years will be similar to Population Zero (10,000 people in a new manufactured city at a time), how would you change your model for the next few migrations? How sustainable are your recruitment and selection processes?

b. Is this long-term plan substantially different than the 10-year plan? Are there elements in your 10-year vision and recommendations that are not sustainable for the 100 year vision? Identify any new parameters or constraints that will ensure your model continues to be effective for the entire 22nd century.

6. In shocking news, scientists discover a threat of a collision of Earth with a planet sized comet. We need to evacuate planet Earth and move as many people as possible to Mars to live in enlarged manufactured cities.

a. Is your model still functional? Would it make a difference if migrations occurred in phases?

b. Study the robustness of your model and comment on its general sensitivity to a much larger scale migration.

c. State the strengths and weaknesses of your model relative to a major migration.

7. Write a policy recommendation addressed to the director of LIFE that includes the factors of

income, education, equality policies based on your model and according to the directions of ICM. Will your recommendations change depending on the composition and size of the Population Zero? Explain the reasoning that led you to your recommendations and analyze the results you are expecting to achieve.

Your ICM submission should consist of a 1 page Summary Sheet, a 1-2 page policy recommendation, and your solution (not to exceed 20 pages) for a maximum of 23 pages. Note: The appendix and references do not count toward the 23 page limit.

References:

<https://www.kansascityfed.org/publications/community/transformworkforce>

<https://www.kansascityfed.org/~media/files/publicat/community/workforce/transformingworkforcedevelopment/book/transformingworkforcedevelopmentpolicies.pdf>

<http://www.economist.com/blogs/freeexchange/2012/01/chinas-labour-force>

ICM2017 问题- F: 迁移到火星: 2100 城市社会的乌托邦劳动力

国际机构, 星际金融与勘探政策实验室 (LIFE), 最近 (在今年的 2095 年) 完成了一系列短期计划的生活实验我们的邻居星球, 火星。新技术, 包括个性化人工增强单元, 将很快使人类能够在 2100 年之前在火星上居住制造的城市。第一波移民潮叫做人口零, 将包括 10,000 人。

LIFE 代理机构启动了 UTOPIA: 2100 项目, 旨在为 22 世纪创造最佳员工队伍, 为所有人提供最高质量的生活, 并在未来 100 年实现可持续发展愿景。在过去 20 年里, 几个计划的社区已经在地球上设计和建造, 测试了几个计划的生活条件。这些社区由经济学, 政府, 劳动力和司法系统中的平等主义原则驱动。

LIFE 正在寻求一套数学和计算模型, 通知国际火星联盟 (ICM) 政府如何设计一个他们可以用零人口实施的经济劳动力教育系统。为了决定采用什么程序, LIFE 聘请了最合格的决策者和数据科学家, 目的是制定一套政策, 实现向火星的迁移。您的三人政策建模小组是顾问和决策者小组的一部分。ICM 已要求您的小组制定一个政策模式和报告, 这将产生一套政策建议, 将创造一个可持续的生活计划, 并将使火星在 2100 年的生活经验甚至比地球上的一年更好的 2095。

网络科学, 系统科学, 复杂系统, 组织和工业心理学以及其他跨学科领域的新工具为理解社会和政府系统提供了新的见解, 具有处理可扩展性问题的能力 (与小群体和大群体相关), 模态 (多层) 和动态 (随时间的变化)。

人口零旨在在许多劳动力和社会生活因素中获得最佳条件 (注意另一个团队正在负责健康政策, 因此 ICM 要求您从您的分析中排除医疗保健)。人口零的使命是通过最大限度地提高经济产出 (GDP) 和幸福来创造一个可持续的社会在其公民的工作地点。当然, 这两个目标可能是相反的, 因此政策建议必须考虑平衡因素, 如:

- 收入: 确保适当的补偿, 使所有人都能负担得起基本必需品 (住所, 食物, 衣服)。
- 教育: 提供高质量的教育, 使公民为 22 世纪的需要和挑战做好准备。
- 平等: 改善妇女在劳动力中的保留, 特别是在她们在地球上代表不足或受到歧视的领域。

您的 ICM 定向任务是:

1. 定义与人口零三个优先因素 (收入, 教育和社会平等) 相关的参数和具体结果。需要考虑的一些问题是: a) 最低工资和工资分配 (收入); b) 高效劳动力所需的技能; 获得这些技能

所需的治理类型和基础设施（教育）；和 c）产假和陪产假，负担得起的儿童保育，以确保人们能够留在劳动力（社会平等）。

a 确定并定义将在未来十年（2100-2110 年）的三个因素中显示出积极成果的具体结果。考虑每个因素的目标是什么；例如，目标是改善所有公民的生活质量或提高系统的产出数量。

b 人口的主要特征（例如人口统计，人口规模和工作条件）将有助于这些结果？

c 创建将用于通过识别和定义三个因素中的每一个的关键参数来评估系统是否满足其目标的度量。

2. 你被要求生成一个 10,000 人的样本人口移民到火星。从人口普查数据集提取数据（链接到一个数据集在下面提供）或综合一个。

a 从你的数据集中，识别和分析人口零模拟的人口统计特征。分析和描述人口分布，如性别，种族，年龄和教育水平。

b 考虑公民的因素分布，这也将有助于实现 UTOPIA: 2100 - 建立一个和平，合作，平等社会的目标。您的数据是否足以确定这些因素？例如，是否应考虑创新者与生产者的分配？熟练劳动与非熟练劳动？家庭与单身人士？

链接到 PUMS 数据（如果您希望使用此人口普查数据）：

- PUMS 数据可以通过以下链接找到：

<http://www.census.gov/programs-surveys/acs/technical-documentation/pums.html>

<http://www2.census.gov/programs-surveys/acs/data/pums/2015/1-Year/>

- 这些链接显示如何提取 R 中的数据：

<https://stat.ethz.ch/R-manual/R-devel/library/base/html/sample.html>

<https://cran.r-project.org/web/packages/sampling/sampling.pdf>

- 此链接显示如何在 MATLAB 中提取数据：

<https://www.mathworks.com/help/stats/datasample.html?requestedDomain=www.mathworks.com>

3. 建立一个包括三个确定因素（收入，教育和社会平等）的模型。使用您在任务 1 中创建的参数，定义未来 10 年成功社会的关键要素。当综合这三个因素时，参数之间的关键相互依存关系是什么？是否需要额外的限制来保持 10 年期间的结果？应该多久对模型进行评估，以确保继续满足 UTOPIA 2100 的目标？在这一时期可能影响模型的可行性的经济，社会，文化和其他全球性因素是什么？基于这些因素和约束，回答以下：

a 确定最佳最低工资和工资分配，以最好地管理福利（更高的生活质量）和支持那些较不能提供劳动服务的人之间的紧张。

b 识别您的模型中可以通过新想法的贡献得到最大改进的术语。描述激励这些新想法的贡献的激励。

c 什么是最好的育儿和陪产假/产假策略？

4. 现在您已经为三个因素创建了模型，继续将这些模型合并到全局模型中。在任务 3 中，您设计了一个模型，为整个社会提供最佳结果。现在，考虑该模型将如何为不同的组运行？

a 确定你的员工的主要分组，并确定他们的主要优先事项。例如，非技术劳动力可能涉及工作时间，残疾照顾，儿童保育和最低工资，而专业人员的优先考虑可能是休假，培训和育儿假。您的模型将决定您考虑哪些子组。您可能需要开发新参数以充分评估每个组的优先级。

b 理解每个小组将有一套不同的需求，观点和成功标准，分析在收入，教育和平等方面满足他们的需求的程度。例如，您的模型在不同教育水平上的功能是否不同？不同年龄段？不同的文化价值观？你的模型对女性或男性是否更好？家庭如何受到影响？

c 考虑到您已确定的小组，您以前的模型可能不再产生最佳结果。通过添加新的约束或参数来调整模型，以优化不同子组的需求。目标是使子群体的优先成果最大化，而不会显着减少

全球结果。

5. LIFE 计划在未来 100 年内分阶段实施额外的迁移。

a 您的模型对于各种迁移阶段的群体选择有多敏感？这个人口的人口分布是否会显著改变结果？你的抽样程序如何影响你的模型？如果未来几年的移民和增长将类似于人口零（一次在一个新的制造城市 10,000 人），你将如何改变您的模型为下几次迁移？你的招聘和选拔过程是否可持续？

b 这个长远计划与十年计划有很大不同吗？你的 10 年愿景和建议中有哪些元素对于 100 年愿景是不可持续的？识别任何新的参数或约束，以确保您的模型在整个 22 世纪继续有效。

6. 在令人震惊的新闻中，科学家发现地球与行星尺寸彗星碰撞的威胁。我们需要疏散行星地球，并尽可能多的人移动到火星住在扩大的制造城市。

a 您的模型是否仍然有效？如果迁移发生在阶段，它会有所不同吗？

b 研究您的模型的鲁棒性，并评论其对更大规模迁移的一般敏感性。

c 说明您的模型相对于主要迁移的优势和弱点。

7. 写一份针对 LIFE 主任的政策建议，其中包括基于您的模型的收入，教育，平等政策等因素，并根据 ICM 的指示。你的建议会根据人口零的组成和规模而改变吗？解释推理，使您得到您的建议，并分析您期望实现的结果。

您的 ICM 提交应包括 1 页的摘要表，1-2 页的政策建议和您的解决方案（不超过 20 页），最多 23 页。注意：附录和参考文献不计入 23 页的限制。

MCM 2018 Problem A: Multi-hop HF Radio Propagation

Background: On high frequencies (HF, defined to be 3 – 30 MHz), radio waves can travel long distances (from one point on the earth's surface to another distant point on the earth's surface) by multiple reflections off the ionosphere and off the earth. For frequencies below the maximum usable frequency (MUF), HF radio waves from a ground source reflect off the ionosphere back to the earth, where they may reflect again back to the ionosphere, where they may reflect again back to the earth, and so on, travelling further with each successive hop. Among other factors, the characteristics of the reflecting surface determine the strength of the reflected wave and how far the signal will ultimately travel while maintaining useful signal integrity. Also, the MUF varies with the season, time of day, and solar conditions. Frequencies above the MUF are not reflected/refracted, but pass through the ionosphere into space. In this problem, the focus is particularly on reflections off the ocean surface. It has been found empirically that reflections off a turbulent ocean are attenuated more than reflections off a calm ocean. Ocean turbulence will affect the electromagnetic gradient of seawater, altering the local permittivity and permeability of the ocean, and changing the height and angle of the reflection surface. A turbulent ocean is one in which wave heights, shapes, and frequencies change rapidly, and the direction of wave travel may also change.

Problem:

Part I: Develop a mathematical model for this signal reflection off the ocean. For a 100-watt HF constant-carrier signal, below the MUF, from a point source on land, determine the strength of the first reflection off a turbulent ocean and compare it with the strength of a first reflection off a calm ocean. (Note that this means that there has been one reflection of this signal off the

ionosphere.) If additional reflections (2 through n) take place off calm oceans, what is the maximum number of hops the signal can take before its strength falls below a usable signal-to-noise ratio (SNR) threshold of 10 dB?

Part II: How do your findings from Part I compare with HF reflections off mountainous or rugged terrain versus smooth terrain?

Part III: A ship travelling across the ocean will use HF for communications and to receive weather and traffic reports. How does your model change to accommodate a shipboard receiver moving on a turbulent ocean? How long can the ship remain in communication using the same multi-hop path?

Part IV: 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.

MCM 2018 问题-A: 多跳 HF 无线电传播

在高频 (HF, 定义为 3-30 MHz) 区域, 通过电离层和地球外的多重反射, 无线电波可以传输较远距离 (从地球表面上的一个点到地球表面上另一个遥远的点)。对于低于最大值 (MUF) 的可用频率, 来自地面源的 HF 无线电波通过电离层反射到地球, 在那里他们可能再次反射回电离层, 或许也可能会再次反映回到地球上, 等等, 每一个连续的跳跃都会使得电波传输的更远。除其他因素外, 反射面的特性决定反射波的强度以及在保证有用信号完整性的同时如何最大程度的传输信号。另外, MUF (最大可用频率) 随季节、一天中的时间及太阳能条件而变化。高于 MUF 的频率不会反射/折射, 而是穿过电离层进入太空。在本问题上, 重点关注在海洋表面的电波反射。根据经验性发现, 在动荡海域表面电波的反射衰减程度会比平静海域大很多。

海洋湍流会影响海水的电磁梯度, 改变海洋的局部介电常数和渗透率, 并改变反射面的高度和角度。动荡海洋表面的波高、形状和频率迅速变化, 且波浪的运动方向也可能改变。

问题:

第一部分: 为通过海洋表层反射的信号建立一个数学模型。对于一个 100 瓦的 HF 恒定载波信号, 其值低于 MUF, 从陆地上的一个点源, 确定在动荡海域的首次反射强度, 并将其与在平静海域的第一次反射强度相比较。(请注意, 这意味着这个信号的有一个反射会从电离层进行。) 如果从平静的海洋发生附加的反射 (2 到 n), 在其强度低于可用信噪比 (SNR) 阈值 10 dB 之前该信号所能采取的最大跳数为多少?

第二部分: 第一部分的研究结果如何与通过山区的 HF 反射进行比较? 或者崎岖的地形与光滑的地形之间如何比较呢?

第三部分: 在海上旅行的船舶将使用 HF 进行通信、接收天气及交通报告。你的模型如何改变, 以适应在动荡的海洋上移动的船上接收器? 当使用多跳路径时, 船还能保持联系

多久?

第四部分: 准备一份简短的 (1 到 2 页) 结果摘要以方便在 IEEE 通信杂志上出版。

MCM 2018 Problem B: How Many Languages?

Background: There are currently about 6,900 languages spoken on Earth. About half the world's population claim one of the following ten languages (in order of most speakers) as a native language: Mandarin (incl. Standard Chinese), Spanish, English, Hindi, Arabic, Bengali, Portuguese, Russian, Punjabi, and Japanese. However, much of the world's population also speaks a second language. When considering total numbers of speakers of a particular language (native speakers plus second or third, etc. language speakers), the languages and their order change from the native language list provided. The total number of speakers of a language may increase or decrease over time because of a variety of influences to include, but not limited to, the language(s) used and/or promoted by the government in a country, the language(s) used in schools, social pressures, migration and assimilation of cultural groups, and immigration and emigration with countries that speak other languages. Moreover, in our globalized, interconnected world there are additional factors that allow languages that are geographically distant to interact. These factors include international business relations, increased global tourism, the use of electronic communication and social media, and the use of technology to assist in quick and easy language translation.

Native Language Rank	Native Language	Family	Native Speakers	Second (or 3rd, etc) Language Speakers	Second Language Rank	Total
1	Mandarin Chinese (incl. Standard Chinese)	Sino-Tibetan, Sinitic	897 million	193 million	4	1.09 billion
2	Spanish	Indo-European, Romance	436 million	91 million	8	527 million
3	English	Indo-European, Germanic	371 million	611 million	1	983 million
4	Hindustani (Hindi/Urdu)	Indo-European, Indo-Aryan	329 million	215 million	2	544 million
5	Arabic	Afro-Asiatic, Semitic	290 million (2017)	132 million	6	422 million
6	Bengali	Indo-European, Indo-Aryan	242 million	19 million in Bangladesh (2011)	13	261 million
7	Portuguese	Indo-European, Romance	218 million	11 million	15	229 million
8	Russian	Indo-European, Slavic	153 million	113 million (2016)	7	267 million
9	Punjabi	Indo-European, Indo-Aryan	148 million	?	?	148 million
10	Japanese	Japonic	128 million	1 million (2010)	19	129 million

Retrieved from https://en.wikipedia.org/wiki/List_of_languages_by_total_number_of_speakers on January 17, 2018.

Problem: A large multinational service company, with offices in New York City in the United States and Shanghai in China, is continuing to expand to become truly international. This company is investigating opening additional international offices and desires to have the employees of each office speak both in English and one or more additional languages. The Chief Operating Officer of the company has hired your team to investigate trends of global languages and location options for new offices.

Part I:

A. Consider the influences and factors described in the background paragraph above, as well as other factors your group may identify. Based on projected trends, and some or all of these influences and factors, model the distribution of various language speakers over time.

B. Use your model to predict what will happen to the numbers of native speakers and total

language speakers in the next 50 years. Do you predict that any of the languages in the current top-ten lists

(either native speakers or total speakers) will be replaced by another language? Explain.

C. Given the global population and human migration patterns predicted for the next 50 years, do the geographic distributions of these languages change over this same period of time? If so, describe the change.

Part II:

A. Based on your modeling from Part I, and assuming your client company wants to open six new international offices, where might you locate these offices and what languages would be spoken in the offices? Would your recommendations be different in the short term versus the long term? Explain your choices.

B. Considering the changing nature of global communications, and in an effort to save your client company resources, might you suggest that the company open less than six international offices? Indicate what additional information you would need and describe how you would analyze this option in order to advise your client.

Part III:

Write a 1-2 page memo to the Chief Operating Officer of the service company summarizing your results and recommendations.

Note: In your analysis, ignore unpredictable or high-impact, low probability events such as asteroid collisions that would cause a catastrophic jump in evolutionary trends over time, and possibly render all languages extinct.

Your submission should consist of:

- One-page Summary Sheet,
- Two-page memo,
- Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and memo.
- Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

The following 26 languages are listed as having 50 million or more total speakers in the 2017 edition of Ethnologue, a language reference published by SIL International based in the United States[2] (although Ethnologue also lists more than only these 26 languages as having 50 million or more total speakers, e.g., the Wikipedia page for the Tagalog language reports 70+ million speakers by as early as 2000 and 73+ million speakers by 2013:

28 million L1 speakers as of 2007 and 45 million L2 speakers as of 2013; these are largely based on Ethnologue reports and would, e.g., unless further updated, rank it as the language with the 26th most L1 speakers, the 13th most L2 speakers, and the 23rd most speakers in total). Speaker totals are generally not reliable, as they add together estimates from different dates and (usually uncited) sources; language information is not collected on most national censuses.

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
1	Mandarin Chinese(incl. Standard Chinese)	Sino-Tibetan, Sinitic	897 million	1	193 million	4	1.09 billion
2	English	Indo-European, Germanic	371 million	3	611 million	1	983 million
3	Hindustani (Hindi/Urdu) ^{[6][7]}	Indo-European, Indo-Aryan	329 million	4	215 million	2	544 million
4	Spanish	Indo-European, Romance	436 million	2	91 million	8	527 million
5	Arabic	Afro-Asiatic, Semitic	290 million (2017)	5	132 million	6	422 million ^{[7][8]}

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
6	Malay (incl. Indonesian and Malaysian)	Austronesian, Malayo-Polynesian	77 million (2007)	15	204 million	3	281 million ^[7]
7	Russian	Indo-European, Slavic	153 million	8	113 million (2010)	7	267 million
8	Bengali	Indo-European, Indo-Aryan	242 million	6	19 million in Bangladesh (2011)	13	261 million
9	Portuguese	Indo-European, Romance	218 million	7	11 million	15	229 million
10	French	Indo-European, Romance	76 million	17	153 million	5	229 million
11	Hausa	Afro-Asiatic, Chadic	85 million	11	65 million	10	150 million ^[9]
12	Punjabi	Indo-European, Indo-Aryan	148 million ^[9]	9	?	?	148 million
13	Japanese	Japonic	128 million	10	1 million (2010) ^[10]	19	129 million

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
14	German	Indo-European, Germanic	76 million	18	52 million	12	129 million
15	Persian	Indo-European, Iranian	60 million (2009)	25	61 million ^[1]	11	121 million ^[1]
16	Swahili	Niger–Congo language, Coastal Tanzanian, Bantu	16 million	26	91 million	8	107 million
17	Telugu	Dravidian	80 million (2011)	13	12 million in India (2011)	14	92 million
18	Javanese	Austronesian, Malayo-Polynesian	84 million (2000)	12	?	?	84 million
19	Wu Chinese (incl. Shanghaiese)	Sino-Tibetan, Chinese	80 million (2013)	14	?	?	80 million
20	Korean	Koreanic	77 million (2008–2010)	16	?	?	77 million
21	Tamil	Dravidian	67 million (2001)	23	8 million in India	16	75 million

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
22	Marathi	Indo-European, Indo-Aryan	71 million (2001)	20	3 million in India	17	74 million
23	Yue Chinese (incl. Cantonese)	Sino-Tibetan, Chinese	72 million	19	?	?	72 million
24	Turkish	Turkic, Oghuz	71 million	21	<1 million	20	71 million
25	Vietnamese	Austroasiatic, Viet–Muong	68 million	22	?	?	68 million
26	Italian	Indo-European, Romance	63 million	24	3 million	17	66 million

Notes

1. Refers to Modern Standard Hindi and Modern Standard Urdu. Modern Hindi and Urdu are mutually intelligible and are

considered by linguists to be dialects of the same language; the two distinct registers are the outcome of nationalist tendencies.[3] The Census of India defines Hindi on a loose and broad basis. In addition to Standard Hindi, it incorporates a set of other Indo-Aryan languages written in Devanagari script including Awadhi, Bhojpuri, Haryanvi, Dhundhari etc. under Hindi group which have more than 422 million native speakers as on 2001.[4] However, the census also acknowledges Standard Hindi, the above mentioned languages and others as separate mother tongues of Hindi language and provides individual figures for all these languages.[4]

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MCM 2018 问题-B: 多少种语言?

背景：目前地球上约有 6,900 种语言。普通话（包括标准中文），西班牙文，英文，印度文，阿拉伯文，孟加拉文，葡萄牙文，俄文，旁遮普文和日文，大约有一半的世界人口是以下十种语言中的一种。但是，全世界的许多人口也会说第二种语言。当考虑特定语言（母语人士，第二或第三等语言使用者）的总发言人数时，语言及其顺序会从提供的母语列表中变化。一种语言的说话人总数可能随着时间的推移而增加或减少，原因来自于各种影响，包括但不限于语言在一国政府使用和/或推广的影响，语言在用于学校，社会压力，文化团体的移民和同化，以及与讲其他语言的国家的移民中的影响。并且在我们这个全球化的，相互联系的世界里，还有另外的因素让地理上遥远的语言能够互动。这些因素包括国际商业关系，日益增长的全球旅游业，电子通讯和社交媒体的使用，以及利用技术来协助快速和简单的翻译。

Native Language Rank	Native Language	Family	Native Speakers	Second (or 3rd, etc) Language Speakers	Second Language Rank	Total
1	Mandarin Chinese (incl. Standard Chinese)	Sino-Tibetan, Sinitic	897 million	193 million	4	1.09 billion
2	Spanish	Indo-European, Romance	436 million	91 million	8	527 million
3	English	Indo-European, Germanic	371 million	611 million	1	983 million
4	Hindustani (Hindi/Urdu)	Indo-European, Indo-Aryan	329 million	215 million	2	544 million
5	Arabic	Afro-Asiatic, Semitic	290 million (2017)	132 million	6	422 million
6	Bengali	Indo-European, Indo-Aryan	242 million	19 million in Bangladesh (2011)	13	261 million
7	Portuguese	Indo-European, Romance	218 million	11 million	15	229 million
8	Russian	Indo-European, Slavic	153 million	113 million (2010)	7	267 million
9	Punjabi	Indo-European, Indo-Aryan	148 million	?	?	148 million
10	Japanese	Japonic	128 million	1 million (2010)	19	129 million

于 2018 年 1 月 17 日从

https://en.wikipedia.org/wiki/List_of_languages_by_total_number_of_speakers 取得

问题：一家在美国纽约市和中国上海设有办事处的大型跨国服务公司正在不断拓展，将成为真正的国际化公司。该公司正在调查开设更多的国际办事处，并希望每个办事处的员工都能用英语和一种或多种其他语言讲话。该公司的首席运营官已经聘请了你的团队来调查全球语言的发展趋势以及新办公室的位置选择。

第一部分：

A. 考虑上述背景段落中描述的影响和因素，以及您的小组可能识别的其他因素。根据预测的趋势，以及这些影响和因素中的一些或全部，随着时间的推移，模拟各种语言使用者的分布。

B. 用你的模型来预测未来 50 年母语人士和总语言使用者（包括母语和非母语）会发生什么变化。您是否预测当前十大名单中的任何一种语言（母语人士或总语言使用者）将被另一种语言所取代？试着解释这个现象。

C. 鉴于未来 50 年预测的全球人口和人口迁移模式，这些语言的地理分布是否在同一时期发生变化？如果是这样，请描述这个变化。

第二部分：答：根据第一部分的建模，假设您的客户公司想要开设六个新的国际办事处，您可以在哪里找到这些办事处以及办公室将使用哪种语言？你的建议在短期和长期上会有所不同吗？解释你的选择。B. 考虑到全球通讯性质的不断变化，为了挽救您的客户公司资源，您是否可以建议公

司开设少于六个国际办事处？指出您需要哪些附加信息，并描述如何分析此选项以便为您的客户提供建议。

第三部分：

向服务公司的首席运营官写一个 1-2 页的 Memo（备忘录），总结你的结果和建议。注意：在您的分析中，请忽略不可预测的或高影响的低概率事件，例如小行星碰撞。这种小概率事件随着时间的推移会导致语言的演化趋势发生灾难性的下跌，并可能使所有语言都灭绝。

您的提交应该包括：

- 单页汇总表，
- 两页 Memo（备忘录），
- 您的解决方案不超过 20 页，最多 23 页，包含摘要和 Memo（备忘录）。
- 注意：参考文献列表和任何附录不计入 23 页的限制，应该写在完成的解决方案后。

附件：List of Languages by Total Numbers of Speakers

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Lane, J. (2017). The 10 Most Spoken Languages in the World. Babbel Magazine. Retrieved from <https://www.babbel.com/en/magazine/the-10-most-spoken-languages-in-the-world> Noack, R. and Gamio, L. (April 23, 2015).

The World's Languages in 7 Maps and Charts. The Washington Post. Retrieved from https://www.washingtonpost.com/news/worldviews/wp/2015/04/23/the-worlds-languages-in-7-maps-and-charts/?utm_term=.a993dc2a15cb

List of Languages by Total Numbers of Speakers
https://en.wikipedia.org/wiki/List_of_languages_by_total_number_of_speakers

List of Languages by Total Numbers of Speakers. Retrieved from
https://en.wikipedia.org/wiki/List_of_languages_by_total_number_of_speakers on January 17, 2018. Ethnologue (2017 20th edition)

民族志（2017 年第 20 版）

以下 26 种语言在 2017 年“民族志”一书中具有 5000 万以上的总讲话者被列出来，这是由 SIL International 在美国出版的一版语言参考文献[2]（尽管民族语言也列出了不止 26 种语言，总共有超过百万人以上讲话者，例如，Tagalog 语言的维基百科页面早在 2000 年就报告了 7 千多万人，到 2013 年为止超过 7 千 3 百万人；2007 年为 2 千 8 百万人，截至 2013 年为 2 千 5 百万人；主要基于民族学的报道，例如，除非进一步更新，否则将其作为语言，将其作为第二十一位最大的发言者，第二十三位发言者和第二十三位最多的发言者。演讲者总数通常是不可靠的，因为他们将来自不同日期的估计值（通常是未被引用的）来源加在一起；大多数国家人口普查都不收集语言信息。

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
1	Mandarin Chinese(incl. Standard Chinese)	Sino-Tibetan, Sinitic	897 million	1	193 million	4	1.09 billion
2	English	Indo-European, Germanic	371 million	3	611 million	1	983 million
3	Hindustani (Hindi/Urdu) ^{[9][10]}	Indo-European, Indo-Aryan	329 million	4	215 million	2	544 million
4	Spanish	Indo-European, Romance	436 million	2	91 million	8	527 million
5	Arabic	Afro-Asiatic, Semitic	290 million (2017)	5	132 million	6	422 million ^{[7][8]}

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
6	Malay (incl. Indonesian and Malaysian)	Austronesian, Malayo-Polynesian	77 million (2007)	15	204 million	3	281 million ^[7]
7	Russian	Indo-European, Slavic	153 million	8	113 million (2010)	7	267 million
8	Bengali	Indo-European, Indo-Aryan	242 million	6	19 million in Bangladesh (2011)	13	261 million
9	Portuguese	Indo-European, Romance	218 million	7	11 million	15	229 million
10	French	Indo-European, Romance	76 million	17	153 million	5	229 million
11	Hausa	Afro-Asiatic, Chadic	85 million	11	65 million	10	150 million ^[8]
12	Punjabi	Indo-European, Indo-Aryan	148 million ^[9]	9	?	?	148 million
13	Japanese	Japonic	128 million	10	1 million (2010) ^[10]	19	129 million

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
14	German	Indo-European, Germanic	76 million	18	52 million	12	129 million
15	Persian	Indo-European, Iranian	60 million (2009)	25	61 million ^[1]	11	121 million ^[1]
16	Swahili	Niger-Congo language, Coastal Tanzanian, Bantu	16 million	26	91 million	8	107 million
17	Telugu	Dravidian	80 million (2011)	13	12 million in India (2011)	14	92 million
18	Javanese	Austronesian, Malayo-Polynesian	84 million (2000)	12	?	?	84 million
19	Wu Chinese (incl. Shanghaiese)	Sino-Tibetan, Chinese	80 million (2013)	14	?	?	80 million
20	Korean	Koreanic	77 million (2008–2010)	16	?	?	77 million
21	Tamil	Dravidian	67 million (2001)	23	8 million in India	16	75 million

Rank	Language	Family	L1 speakers	L1 Rank	L2 speakers	L2 Rank	Total
22	Marathi	Indo-European, Indo-Aryan	71 million (2001)	20	3 million in India	17	74 million
23	Yue Chinese (incl. Cantonese)	Sino-Tibetan, Chinese	72 million	19	?	?	72 million
24	Turkish	Turkic, Oghuz	71 million	21	<1 million	20	71 million
25	Vietnamese	Austroasiatic, Viet-Muong	68 million	22	?	?	68 million
26	Italian	Indo-European, Romance	63 million	24	3 million	17	66 million

注释：

1.指现代标准印地语和现代标准乌尔都语。现代印度语和乌尔都语是相互理解的，被语言学家认为是同一种语言的方言；两个不同的登记册是民族主义倾向的结果。[3] 印度人口普查在宽松和广泛的基础上定义了印度语。除标准印地语之外，还包括一系列以梵文字编写的其他印度语 - 雅利安语言，其中包括在印地语小组中使用的 Awadhi, Bhojpuri, Haryanvi, Dhundhari 等，2001 年有超过 4.22 亿以英语为母语的人。[4] 然而，人口普查也承认标准印地语，上述语言和其他语言是独立的印地语母语，并提供所有这些语言的个人数字。

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 10. "Japanese". Ethnologue. Retrieved 2016-03-07.
 11. Windfuhr, Gernot: The Aryan Languages, Routledge 2009,
- 小米辣数学建模工作室整理
<https://shop396884819.taobao.com/?spm=2013.1.1000126.d21.20a0bdf721CVx2>

MCM 2018 Problem C: Energy Production

Background: Energy production and usage are a major portion of any economy. In the United States, many aspects of energy policy are decentralized to the state level. Additionally, the varying geographies and industries of different states affect energy usage and production. In 1970, 12 western states in the U.S. formed the Western Interstate Energy Compact (WIEC), whose mission focused on fostering cooperation between these states for the development and management of nuclear energy technologies. An interstate compact is a contractual arrangement made between two or more states in which these states agree on a specific policy issue and either adopt a set of standards or cooperate with one another on a particular regional or national matter.

Problem: Along the U.S. border with Mexico, there are four states – California (CA), Arizona (AZ), New Mexico (NM), and Texas (TX) – that wish to form a realistic new energy compact focused on increased usage of cleaner, renewable energy sources. Your team has been asked by the four governors of these states to perform data analysis and modeling to inform their development of a set of goals for their interstate energy compact.

The attached data file “ProblemCData.xlsx” provides in the first worksheet (“seseds”) 50 years of data in 605 variables on each of these four states’ energy production and consumption, along with some demographic and economic information. The 605 variable names used in this dataset are defined in the second worksheet (“msncodes”).

- A. Using the data provided, create an energy profile for each of the four states.
- B. Develop a model to characterize how the energy profile of each of the four states has

evolved from 1960 – 2009. Analyze and interpret the results of your model to address the four states’ usage of cleaner, renewable energy sources in a way that is easily understood by the governors and helps them to understand the similarities and difference between the four states. Include in your discussion possible influential factors of the similarities and differences (e.g. geography, industry, population, and climate).

C. Determine which of the four states appeared to have the “best” profile for use of cleaner, renewable energy in 2009. Explain your criteria and choice.

D. Based on the historical evolution of energy use in these states, and your understanding of the differences between the state profiles you established, predict the energy profile of each state, as you have defined it, for 2025 and 2050 in the absence of any policy changes by each governor’s office.

Part II:

A. Based on your comparison between the four states, your criteria for “best” profile, and your predictions, determine renewable energy usage targets for 2025 and 2050 and state them as goals for this new four-state energy compact.

B. Identify and discuss at least three actions the four states might take to meet their energy compact goals.

Part III:

Prepare a one-page memo to the group of Governors summarizing the state profiles as of 2009, your predictions with regard to energy usage absent any policy changes, and your recommended goals for the energy compact to adopt.

Your submission should consist of:

One-page Summary Sheet,

One-page memo,

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

Note: Reference list and any appendices do not count toward the 22-page limit and should appear after your completed solution.

Attachments:

ProblemCData.xlsx

Includes two worksheets seseds and msnccodes.

References:

State Energy Data System (SEDS) Complete Dataset through 2009 (All 50 states)
<https://catalog.data.gov/dataset/state-energy-data-system-seds-complete-dataset-through-2009#sec-dates>

MCM 2018 问题-C: 能源生产

背景：能源生产和使用是任何经济的主要部分。在美国，能源政策的许多方面分散到国家层面。此外，不同国家的不同地区和行业也影响能源使用和生产。 1970

年，美国的 12 个西方国家组建了西部州际能源契约（WIEC），其使命的重点是 促进

这些州之间的合作，以开发和管理核能技术。州际契约是两个或两个以上的州之间的合同安排，在这两个州之间，就具体的政策问题达成一致，并采取一套标准或就某一地区或国家事务相互合作。问题：在美国与墨西哥的边界上，有四个州 - 加利福尼亚州（CA），亚利桑那州

（AZ），新墨西哥州（NM）和德克萨斯州（Texas） - 希望就清洁和可再生能源的广泛使用形成一个现实的新能源契约。您的团队已经被这些州的四位州长要求进行数据分析和建模，以便为他们的州际能源契约制定一套目标。附加的数据文件“ProblemCData.xlsx”在第一个工作表（“seseds”）中提供了这四个州的能源生产和消费中的 605 个变量的 50 年数据以及一些人口和经济信息。在这个数据集中使用的 605 个变量名在第二个工作表（“msncodes”）中定义。第一部分：

A.使用提供的数据，为四个州中的每一个创建一个能源概况。 B.开发一个模型来描述 1960 年至 2009 年四个州中每个州的能源状况。从分析和解释模型的结果可以看出，四个州使用清洁的可再生能源的方式是让州长们很容易理解，帮助他们了解这四个州之间的异同。在你的讨论中加入可能影响相似性和差异性的因素（如地理，行业，人口和气候）。

C.确定 2009 年四个州中哪一个看起来具有“最好”的使用清洁可再生能源的概况。解释你的标准和选择。 D.根据这些国家能源使用的历史演变，以及你对你所建立的国家概况之间的差异的理解，按照你的定义，预测 2025 年和 2050 年在各州长办公室没有政策调整的情况下，每个国家的能源概况。

第二部分：根据你们四国之间的比较，你们对“最佳”概况和你们预测的标准决定了 2025 年和 2050 年的可再生能源使用目标，并将它们作为这个新的四国能源契约的目标。

B.确定并讨论四个州为达到其能源紧凑目标可能采取的至少三项行动。第三部分：

准备一份长达一页的总结备忘录，概述截至 2009 年的状态概况，您没有任何政策变化的能源使用预测，以及能源契约采纳的建议目标。您的提交应包括：

- 单页汇总表，
- 单页备忘录，
- 您的解决方案不超过 20 页，最多 22 页的摘要和备忘录。
- 注意：参考列表和任何附录不计入 22 页的限制，应在完成的解决方案后出现。

附件：ProblemCData.xlsx 包括 seseds 和 msncodes 两个工作表。参考文献：州能源数据系统（SEDS）2009 年全部数据集（所有 50 个州）

<https://catalog.data.gov/dataset/state-energy-data-system-seds-complete-dataset-through-2009#sec-dates>

小米辣数学建模工作室整理

<https://shop396884819.taobao.com/?spm=2013.1.1000126.d21.20a0bdf721CVx2>

ICM 2018 Problem D: Out of Gas and Driving on E (for electric, not empty)

For both environmental and economic reasons, there is global interest in reducing the use of fossil fuels, including gasoline for cars. Whether motivated by the environment or by the economics, consumers are starting to migrate to electric vehicles. Several countries are seeing early signs of the potential for rapid growth in the adoption of electric vehicles. In the US and

other countries, the release of the more affordable all-electric Tesla Model 3 has resulted in record numbers of pre-orders and long wait lists (<https://www.wired.com/story/tesla-model-3-delivery-timeline/>). To further accelerate the switch to electric vehicles, some countries, including China, have announced that they will ban gasoline and diesel cars in the coming years (<http://money.cnn.com/2017/09/11/news/china-gas-electric-car-ban/index.html>).

Eventually, when a ban goes into effect, there needs to be a sufficient number of vehicle charging stations in all the right places so that people can use their vehicles for their daily business, as well as make occasional long-distance trips. The migration from gasoline and diesel cars to electric vehicles, however, is not simple and can't happen overnight. In a fantasy world, we would wake up one day with every gas vehicle replaced by an electric one, and every gas station replaced with a charging station. In reality, there are limited resources, and it will take time for consumers to make the switch. In fact, the location and convenience of charging stations is critical as early adopters and eventually mainstream consumers volunteer to switch (<http://www.govtech.com/fs/Building-Out-Electric-Vehicle-Infrastructure-Where-Are-the-Best-Locations-for-Charging-Stations.html>).

As nations plan this transition, they need to consider the final network of charging stations (the number of stations, where they will be located, the number of chargers at the stations, and the differences in the needs of rural areas, suburban areas, and urban areas), as well as the growth and evolution of the network of charging stations over time. For example, what should the network look like when electric vehicles represent 10% of all cars, 30% of all cars, 50% of all cars, and 90% of all cars?

As nations seek to develop policies that promote the migration towards electric vehicles, they will need to design a plan that works best for their individual country. Before they can begin, they would like your team's help in determining the final architecture of the charging network to support the full adoption of all-electric vehicles. Additionally, they would like you to identify the key factors that will be important as they plan their timeline for an eventual ban or dramatic reduction of gasoline and diesel vehicles.

To help your team manage the scope of this problem, we ask that you focus only on personal passenger vehicles (i.e. cars, vans, and light trucks used for passengers). At the end of your report, you may briefly comment on the relevance of your findings and conclusions on commercial vehicles to include heavy trucks and busses.

Your tasks are the following:

Task 1: Explore the current and growing network of Tesla charging stations in the United States. Tesla currently offers two types of charging stations: (1) destination charging designed for charging for several hours at a time or even overnight (<https://www.tesla.com/destination-charging>) ; and (2) supercharging designed for longer road trips to provide up to 170 miles of range in as little as 30 minutes of charging (<https://www.tesla.com/supercharger>). These stations are in addition to at-home

charging used by many Tesla owners who have a personal garage or a driveway with power. Is Tesla on track to allow a complete switch to all-electric in the US? If everyone switched to all-electric personal passenger vehicles in the US, how many charging stations would be needed, and how should they be distributed between urban, suburban, and rural areas?

Task 2: Select one of the following nations (South Korea, Ireland, or Uruguay).

2a. Determine the optimal number, placement, and distribution of charging stations if your country could migrate all their personal passenger vehicles to all-electric vehicles instantaneously (no transition time required). What are the key factors that shaped the development of your plan?

2b. While these countries have already started installing chargers, you get to start with a clean slate. Present a proposal for evolving the charging network of your chosen country from zero chargers to a full electric-vehicle system. How do you propose the country invest in chargers? Should the country build all city-based chargers first, or all rural chargers, or a mix of both? Will

you build the chargers first and hope people buy the cars, or will you build chargers in response to car purchases? What are the key factors that shaped your proposed charging station plan?

2c. Based on your growth plan, what is the timeline you propose for the full evolution to electric vehicles in your country? To get started, you may wish to consider how long it will take for there to be 10% electric vehicles, 30% electric vehicles, 50% electric vehicles, or 100% electric vehicles on your selected country's roads. What are the key factors that shaped your proposed growth plan timeline?

Task 3: Now consider countries with very different geographies, population density distributions, and wealth distributions, such as Australia, China, Indonesia, Saudi Arabia, and Singapore. Would your proposed plan for growing and evolving the network of chargers still apply to each of these countries? What are the key factors that trigger the selection of different approaches to growing the network?

Discuss the feasibility of creating a classification system that would help a nation determine the general growth model they should follow in order for them to successfully migrate away from gasoline and diesel vehicles to all electric cars.

Task 4: The technological world continues to change and is impacting transportation options such as car-share and ride-share services, self-driving cars, rapid battery-swap stations for electric cars, and even flying cars and a Hyperloop. Comment on how these technologies might impact your analyses of the increasing use of electric vehicles.

Task 5: Prepare a one-page handout written for the leaders of a wide range of countries who are attending an international energy summit. The handout should identify the key factors the leaders should consider as they return to their home country to develop a national plan to migrate personal transportation towards all-electric cars and set a gas vehicle-ban date.

Your submission should consist of:

- One-page Summary Sheet,
- One-page handout,
- Your solution of no more than 20 pages, for a maximum of 22 pages with your summary and handout.
- Note: Reference list and any appendices do not count toward the 22-page limit and should appear after your completed solution.

ICM 2018 问题-D: 停止使用燃气和用电驾驶（电，不是空的）

由于环境和经济原因，全球都有兴趣减少使用化石燃料，包括汽车用汽油。无论是受环境或经济动机，消费者开始转向电动汽车。几个国家正在看到采用电动汽车快速增长的潜力。在美国和其他国家，更经济实惠的全电式特斯拉 3 型车型的发布带来了预购订单和长期等待名单的记录

(<https://www.wired.com/story/tesla-model-3-delivery-timeline/>)。为了进一步加快向电动汽车的转型，包括中国在内的一些国家已经宣布将在未来几年内禁止汽油和柴油车

(<http://money.cnn.com/2017/09/11/news/china-gaselectric-car-ban/index.html>)。最终，禁令生效时，要在所有的地方都有充足的车辆充电站，以便人们可以把车辆用于日常事务，也可以进行偶尔的长途旅行。然而，从汽油车和柴油车到电动车的过渡并不是一帆风顺的，不能一蹴而就。在一个幻想的世界里，我们会有一天醒来，每一辆汽车都换上一辆电动汽车，每一辆加油站都换上一个充电站。实际上资源有限，消费者需要时间进行转换。事实上，充电站的位置和方便性对于早期使用者以及最终主流消费者自愿切换是至关重要的

(<http://www.govtech.com/fs/Building-Out-Electric-Vehicle-Infrastructure-Where-Are-the-Best-Locations-for-Charging-Stations.html>)。当国家计划这一转型时，他们需要考

虑充电站的最终网络（车站的数量，所在的位置，车站充电器的数量以及农村，郊区的需求的差异，以及城市地区）以及充电站网络的发展和演变。例如，当电动汽车占有所有汽车的 10%，所有汽车的 30%，所有汽车的 50% 以及所有汽车的 90% 时，网络应该如何？随着各国寻求制定促进向电动汽车过渡的政策，他们将需要制定一个最适合其个别国家的计划。在他们开始之前，他们希望您的团队帮助确定充电网络的最终架构，以支持全电动车辆的全面采用。此外，他们希望您确定在规划最终禁止汽油车辆和柴油车辆大幅度减少的时间表时将起重要作用的关键因素。为了帮助您的团队管理这个问题的范围，我们要求您只关注个人乘用车（即用于乘客的轿车，货车和轻型卡车）。在你的报告结尾，你可以简要地评论你的发现和商业车辆的结论的相关性，包括重型卡车和公共汽车。

您的任务如下：

任务 1：探索美国当前日益增长的特斯拉充电站网络。特斯拉目前提供两种类型的充电站：（1）目的地充电设计为一次或甚至一夜充电数小时

（<https://www.tesla.com/destination-charging>）；和（2）增压设计用于长途旅行，在短短 30 分钟的充电时间内提供 170 英里的行驶里程

（<https://www.tesla.com/supercharger>）。除了拥有私人车库或车道的许多特斯拉车

主所使用的这些车站之外，这些车站也是如此。特斯拉正走在美国的一个完全切换到全电的轨道上吗？如果每个人都在美国转而使用全电动个人乘用车，那么需要多少个充电站，又如何在城市，郊区和农村之间进行分配呢？

任务 2：选择下列国家之一（南韩，爱尔兰或乌拉圭）。

2a. 确定充电站的最佳数量，布局 and 分布，如果您的国家可以将所有个人乘用车瞬间迁移到全电动汽车（不需要过渡时间）。影响你计划发展的关键因素是什么？2b. 当这些国家已经开始安装充电器的时候，你可以从一个干净的石板开始。提出将您所选择的国家的充电网络从零充电器发展到全电动车系统的建议。你如何提出该国投资于充电器？该国是否应该首先建立所有城市的充电器，或者所有的农村充电器，还是两者兼而有之？你会先建立充电器，并希望人们购买汽车，或者你会建立充电器，以应付汽车购买？建议的充电站计划的关键因素是什么？2c. 根据你的成长计划，你提出的全面演进的时间表是什么？你们国家的电动汽车？要开始，你不妨考虑要花多长时间有 10% 的电动车，30% 的电动车，50% 的电动车，或 100% 的电动车在您选择的国家道路上。什么是影响您提出的增长计划时间表的关键因素？

任务 3：现在考虑具有非常不同地理位置，人口密度分布和地理位置的国家澳大利亚，中国，印度尼西亚，沙特阿拉伯和新加坡等财富分布。你提出的增长和发展收费网络的计划仍然适用于每个这些国家吗？触发选择不同增长网络的关键因素是什么？讨论建立一个帮助一个国家确定的分类体系的可行性他们应该遵循一般的成长模式，以便他们成功地从汽油中迁移出来和柴油车到所有电动车。任务 4：技术世界不断变化，正在影响交通选择，如汽车共享和乘车分享服务，自驾车，电动汽车的快速换电站等即使是飞行的汽车和超环。评论这些技术如何影响你的分析电动车的使用日益增多。

任务 5：为广泛的国家的领导人准备一份单页的执行计划参加国际能源峰会。执行计划应该确定领导者的关键因素应当考虑返回本国制定国家移民个人计划运输全电动汽车，并设置禁止汽油的日期。

您的提交应该包括：

- 单页摘要，
 - 单页执行计划，
 - 您的解决方案不超过 20 页，最多 22 页的摘要和执行计划。
- 注意：参考列表和任何附录不计入 22 页的限制，应该这样做在完成解决方案后出现。

小米辣数学建模工作室整理

<https://shop396884819.taobao.com/?spm=2013.1.1000126.d21.20a0bdf721CVx2>

ICM 2018 Problem E: How does climate change influence regional instability?

The effects of Climate Change, to include increased droughts, shrinking glaciers, changing animal and plant ranges, and sea level rise, are already being realized and vary from region to region. The Intergovernmental Panel on Climate Change suggests that the net damage costs of climate change are likely to be significant. Many of these effects will alter the way humans live, and may have the potential to cause the weakening and breakdown of social and governmental structures. Consequently, destabilized governments could result in fragile states.

A fragile state is one where the state government is not able to, or chooses not to, provide the basic essentials to its people. For the purpose of this problem “state” refers to a sovereign state or country. Being a fragile state increases the vulnerability of a country’s population to the impact of such climate shocks as natural disasters, decreasing arable land, unpredictable weather, and increasing temperatures. Non-sustainable environmental practices, migration, and resource shortages, which are common in developing states, may further aggravate states with weak governance (Schwartz and Randall, 2003; Theisen, Gleditsch, and Buhaug, 2013). Arguably, drought in both Syria and Yemen further exacerbated already fragile states. Environmental stress alone does not necessarily trigger violent conflict, but evidence suggests that it enables violent conflict when it combines with weak governance and social fragmentation. This confluence can enhance a spiral of violence, typically along latent ethnic and political divisions (Krakowka, Heimel, and Galgano 2012).

Your tasks are the following:

Task 1: Develop a model that determines a country’s fragility and simultaneously measures the impact of climate change. Your model should identify when a state is fragile, vulnerable, or stable. It should also identify how climate change increases fragility through direct means or indirectly as it influences other factors and indicators.

Task 2: Select one of the top 10 most fragile states as determined by the Fragile State Index (<http://fundforpeace.org/fsi/data/>) and determine how climate change may have increased fragility of that country. Use your model to show in what way(s) the state may be less fragile without these effects.

Task 3: Use your model on another state not in the top 10 list to measure its fragility, and see in what way and when climate change may push it to become more fragile. 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 climate change and prevent a country from becoming a fragile 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?

Your submission should consist of:

- One-page Summary Sheet,
- Your solution of no more than 20 pages, for a maximum of 21 pages with your summary.
- Note: Reference list and any appendices do not count toward the 21-page limit and should appear after your completed solution.

References:

Krakowka, A.R., Heimel, N., and Galgano, F. "Modeling Environmental Security in Sub-Saharan Africa – ProQuest." The Geographical Bulletin, 2012, 53 (1): 21-38.

Schwartz, P. and Randall, D. "An Abrupt Climate Change Scenario and Its Implications for United States National Security", October 2003.
<http://eesc.columbia.edu/courses/v1003/readings/Pentagon.pdf>

Theisen, O.M., Gleditsch, N.P., and Buhaug, H. "Is climate change a driver of armed conflict?"

Climate Change, April 2013, V117 (3), 613-625.

Helpful Links:

Fragile States Index: <http://fundforpeace.org/fsi/>

The World Bank:
<http://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonized-list-of-fragile-situations>

ICM 2018 问题-E: 气候变化如何影响地区不稳定?

气候变化的影响已经发生并且因地区不同而不同，这些变化包括持续增加的 干旱、冰川萎缩、动植物种类变化以及海平面上升。政府间气候变化专门委员会 认为，气候变化导致的净损害成本可能很大。这些影响中的很多会改变人类的生 活方式，并有可能导致社会和政府结构的弱化和崩溃。因此，不稳定的政府可能 会导致国家的脆弱。

脆弱的国家是指政府无法或者不愿意为人民提供基本要素的国家。就问题本 身而言，“国家”是指一个主权国家或国家。脆弱的国家增加了该国人口遭受诸如 自然灾害，减少耕地，不可预测的天气和气温升高等气候冲击的影响。发展中国 家普遍存在的不可持续的环境实践，移民和资源短缺可能会进一步加剧治理不力 国家的情况。(Schwartz and Randall, 2003; Theisen, Gleditsch, and Buhaug, 2013) 。可以说，叙利亚和也门的干旱进一步加剧了国家情况的恶化。环境压力本身并不 一定会引发暴力冲突，但有证据表明，当它与治理薄弱和有社会分裂的国家相结 合的时候，它就会导致暴力冲突。这种融合可以加剧暴力的持续，典型的是潜在 的种族问题和政治分歧问题 (Krakowka, Heimel, and Galgano 2012)) 你的任务如下： 任务一：制定一个模型来衡量一个国家的脆弱性，同时衡量气候变化的影响。你的模型应该能够在国家的脆弱、相对脆弱和稳定的三种情况下均可行。还应该确 定气候变化如何通过直接或间接的手段影响其他因素和指标来增加脆弱性。

任务二：选择由脆弱国家指数确定的十大最脆弱国家之一

(<http://fundforpeace.org/fsi/data/>)，并确定气候变化如何增加该国的脆弱性。使用你的模型表明如何减少国家的脆弱性。 任务三：在另一个不在前十名单的国家使用你的模型来衡量其脆弱性，看看气候 变化如何推动它变得更加脆弱。确定任何明确的指标。你如何定义一个临界点， 并预测一个国家何时可以达到这个临界点？ 任务四：使用你的模型来显示哪种状态下的干预可以减轻气候变化带来的风险，并防止一个国家变成一个脆弱的国家。解释人为干预的影响，并预测该国进行干 预时所产生的总成本。 任务五：你的模型可以在较小的“州”（比如城市）或者更大的“州”（比如 洲）工作吗？如果不行，应如何修改你的模型？

你的提交应该包含下面这些：

- 一页总结表 (One-page Summary Sheet)
- 您的解决方案不超过 20 页，最多加上您的摘要共 21 页。
- 注意：参考列表和任何附录不计入 21 页的限制，应在完成的解决方案后给 出。

参考：

Krakowka, A.R., Heimel, N., and Galgano, F. "Modeling Environmental Security in Sub-Saharan Africa – ProQuest." *The Geographical Bulletin*, 2012, 53 (1): 21-38.

Schwartz, P. and Randall, D. "An Abrupt Climate Change Scenario and Its Implications for United States National Security", October 2003.
<http://eesc.columbia.edu/courses/v1003/readings/Pentagon.pdf>

Theisen, O.M., Gleditsch, N.P., and Buhaug, H. "Is climate change a driver of armed conflict?" *Climate Change*, April 2013, V117 (3), 613-625.

有帮助的链接:

Fragile States Index: <http://fundforpeace.org/fsi/> The World Bank:

<http://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonizedlist-of-fr-agile-situations>

ICM 2018 Problem F: Cost of Privacy

Pervasiveness of, and reliance on, electronic communication and social media have become widespread. One result is that some people seem willing to share private information (PI) about their personal interactions, relationships, purchases, beliefs, health, and movements, while others hold their privacy in these areas as very important and valuable. There are also significant differences in privacy choices across various domains. For example, some people are quick to give away the protection of their purchasing information for a quick price reduction, but at the same time are unlikely to share information about their disease conditions or health risks.

Similarly, some populations or subgroups may be less willing to give up particular types of personal information if they perceive it posing a personal or community risk. The risk may involve loss of safety, money, valuable items, intellectual property (IP), or the person's electronic identity. Other risks include professional embarrassment, loss of a position or job, social loss (friendships), social stigmatization, or marginalization. While a government employee who has voiced political dissent against the government might be willing to pay to keep their social media data private, a young college student may feel no pressure to restrict their posting of political opinion or social information. It seems that individual choices on PI protection and internet and system security in cyber space can create risks and rewards in elements of freedom, privacy, convenience, social standing, financial benefits, and medical treatment.

Is private information (PI) similar to private personal property (PP) and intellectual property (IP)? Once lawfully obtained, can PI be sold or given to others who then have the right or ownership of the information? As detailed information and meta-data of human activity becomes more and more valuable to society, specifically in the areas of medical research, disease spread, disaster relief, businesses (e.g. marketing, insurance, and income), records of personal behaviors, statements of beliefs, and physical movement, these data and detailed information may become a valuable and quantifiable commodity. Trading in one's own private data comes with a set of risks and benefits that may differ by the domain of information (e.g. purchasing, social media, medical) and by subgroup (e.g. citizenship, professional profile, age).

Can we quantify the cost of privacy of electronic communications and transactions across society? That is, what is the monetary value of keeping PI protected, or how much would it cost for others to have or use PI? Should the government regulate this information or is it better left to privacy industry or the individual? Are these information and privacy issues merely personal decisions that individuals must evaluate to make their own choices and provide their own protection?

There are several things to consider when evaluating the cost of privacy. First, is data sharing a public good? For example, Center for Disease Control may use the data to trace the spread of disease in order to prevent further outbreak. Other examples include managing at risk populations, such as children under 16, people at risk of suicide, and the elderly. Moreover, consider groups of extremists who seek to hide their activities. Should their data be trackable by the government for

national security concerns? Consider a person's browser, phone system, and internet feed with their personalized advertisements; how much is this customization worth?

Overall, when evaluating cost of privacy we need to consider all of these tradeoffs. What is the potential gain from keeping data private and what is lost by doing so?

As a policy analysis team for a national decision maker, your team's tasks are:

Task 1: Develop a price point for protecting one's privacy and PI in various applications. To evaluate this, you may want to categorize individuals into subgroups with reasonably similar levels of risk or into related domains of the data. What are the set of parameters and measures that would need to be considered to accurately model risk to account for both 1) characteristics of the individuals, and 2) characteristics of the specific domain of information?

Task 2: Given the set of parameters and measures from Task 1, model for cost of privacy across at least three domains (social media, financial transactions, and health/medical records). In your base model consider how the tradeoffs and risks of keeping data protected affect your model.

You may consider giving some of the tradeoffs and risks more weight than others as well as stratifying weights by subgroup or category. Consider how different basic elements of the data (e.g. name, date of birth, gender, social security or citizenship number) contribute to your model. Are some of these elements worth more than others? For example, what is the value of a name alone compared with value of a name with the person's picture attached? Your model should design a pricing structure for PI.

Task 3: Not long ago, people had no knowledge about which agencies had purchased their PI, how much their PI was worth, or how PI was being used. New proposals are being put forth which would turn PI into a commodity. With the pricing structure you generated in Task 2, establish a pricing system for individuals, groups, and entire nations. With data becoming a commodity subject to market fluctuations, is it appropriate to consider forces of supply and demand for PI? Assuming people have control to sell to their own data, how does this change the model?

Task 4: What are the assumptions and constraints of your model? Assumptions and constraints should address issues such as government regulations (e.g. price regulations, specific data protections such as certain records that may not be subject to the economic system) and cultural and political issues. Based on your model and the political and cultural issues, consider if information privacy should be made a basic human right when thinking about policy recommendations. Consider introducing a dynamic element to your model by introducing the variations over time in human decision-making given changing personal beliefs about the worth of their own data (e.g. personal data such as name, address, picture), transaction data (e.g. on-line purchases, search history), and social media data (e.g. posts, pictures).

Task 5: Are there generational differences in perceptions of the risk-to-benefit ratio of PI and data privacy? As generations age, how does this change the model? How is PI different or similar to PP and IP?

Task 6: What are the ways to account for the fact that human data is highly linked and often each individual's behaviors are highly correlated with others? Data on one person can provide information about others whom they are socially, professionally, economically, or

demographically connected. Therefore, personal decisions to share one's own data can affect countless others. Are there good ways to capture the network effects of data sharing? Does that effect the price system for individuals, subgroups, and entire communities and nations? If communities have shared privacy risks, is it the responsibility of the communities to protect citizens' PI?

Task 7: Consider the effects of a massive data breach where millions of people's PI are stolen and sold on the dark web, sold as part of an identity theft ring, or used as ransom. How does such

a PI loss or cascade event impact your model? Now that you have a pricing system that quantifies the value of data per individual or loss type, are agencies that are to blame for the data breach responsible to pay individuals directly for misuse or loss of PI?

Task 8: Write a two-page policy memo to the decision maker on the utility, results, and recommendations based your policy modeling on this issue. Be sure to specify what types of PI are included in your recommendations.

Your submission should consist of:

- One-page Summary Sheet,
 - Two-page memo,
 - Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and memo.
- Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

ICM 2018 问题 F: 隐私成本

电子传播和社交媒体的普及和依赖已经变得普遍。其中一个结果是，有些人似乎愿意分享关于他们的个人交往，关系，购买，信仰，健康和运动的私人信息（PI， private information），而另一些人则认为这些方面的隐私非常重要和有价值。不同领域的隐私选择也有显著差异。例如，一些人会迅速放弃购买信息的保护，以便迅速降价，但同时他们不太可能共享有关其疾病状况或健康风险的信息。同样，如果某些人群或子群体认为个人信息构成了个人或社区风险，他们可能不愿意放弃特定类型的个人信息。风险可能涉及安全，金钱，贵重物品，知识产权（IP）或个人电子身份的损失。其他风险包括职业尴尬，失去职位或工作，社交损失（友谊），社会耻辱或边缘化。虽然对政府表示异议的政府工作人员可能愿意为保留其社交媒体数据而付费，但一位年轻的大学生可能不会对限制他们发表政治观点或社会信息感到任何压力。网络空间中个人信息保护，互联网和系统安全的个人选择似乎可以在自由，隐私，便利，社会地位，经济利益和医疗等方面创造风险和回报。

私人信息（PI）是否与私人财产（PP）和知识产权（IP）类似？一旦合法获得，PI 可以被出售或给予给他人，然后他人便拥有该信息的权利或所有权？随着人类活动的详细信息和元数据对于社会越来越重要，尤其是在医学研究，疾病传播，救灾，企业（如营销，保险和收入），个人行为记录，信仰和身体活动这些方面，这些数据 and 详细信息可能成为一种有价值 and 可量化的商品。交易自己的私人数据带有一系列风险和收益，这些风险和收益可能因信息领域（例如购买，社交媒体，医疗）和小组（例如公民身份，专业背景，年龄）而有所不同。

我们能否量化整个社会电子通讯和交易的隐私成本？也就是说，保持 PI 的货币价值是多少，或者其他拥有或使用 PI 的成本是多少？政府应该调整这些信息还是留给隐私行业或个人呢？这些信息和隐私问题只是个人决定，个人必须评估自己的选择和提供自己的保护？

评估隐私成本时需要考虑几件事情。首先，数据分享是否是公共物品？例如，疾病预防控制中心可以使用这些数据来追踪疾病的传播，以防止进一步的暴发。其他例子包括管理危险人群，如 16 岁以下的儿童，有自杀风险的人和老人。此外，还要考虑一些试图隐藏自己活动的极端主义分子，为了国家安全问题他们的数据是否可以由政府追踪？考虑一个公民

的浏览器、电话系统和有个性化的广告的互联网，这个定制值多少钱？

总的来说，在评估隐私成本时，我们需要考虑所有这些权衡。保持数据隐私的潜在收益是什么？这样做会导致什么损失？

作为国家决策者的政策分析团队，您的团队的任务是：

任务 1：在各种应用程序中制定保护个人隐私和 PI 的价格点。为了对此进行评估，您可能希望将个人分类到具有相当相似风险水平的亚组或数据的相关领域。为了准确地模拟风险，需要考虑哪些参数和措施？1) 个人的特征，2) 特定信息领域的特征？

任务 2：从任务 1 给出的参数和度量，至少在三个领域（社交媒体，金融交易和 健康/医疗记录）建立隐私成本模型。在您的基础模型中，考虑保持数据保护的权衡和风险如何影响您的模型。您可能会考虑给予一些权衡和风险更多的权重，并按分组或类别对权重进行分层。考虑数据的不同基本要素（例如姓名，出生日期，性别，社会保障或公民身份号码）如何对您的模型作出贡献。这些元素中是否有些比其他元素更值钱？例如，与附有该人的照片的姓名的价值相比，单独一个姓名的价值是多少？您的模型应该为 PI 设计一个定价结构。

任务 3：不久之前，人们不知道哪个机构购买了 PI，他们的 PI 值多少，或者 PI 如何使用。现在提出的新的提案，会将 PI 变成商品。利用您在任务 2 中产生的定价结构，为个人，团体和整个国家建立定价体系。随着数据成为受到市场波动影响的商品，考虑供应和需求的力量是否合适？假设人们有控制权来销售他们自己的数据，这是如何改变模型的？

任务 4：你的模型有哪些假设和限制？假设和约束条件应该解决诸如政府法规（例如价格法规，具体的数据保护，例如可能不受经济制度约束的某些记录）以及文化和政治问题等问题。根据你的模式和政治和文化问题，考虑一下在考虑政策建议时是否应把信息隐私作为基本人权。考虑改变个人对自身数据价值（如姓名，地址，图片等个人数据）的个人信念，交易数据（如在线），引入人类决策随时间变化的动态因素（购买，搜索历史）和社交媒体数据（例如帖子，图片）。

任务 5：在 PI 和数据隐私的风险收益比的观念上是否存在代际差异？随着年龄的增长，这是如何改变模型的？PI 和 PP 和 IP 有什么不同？

任务 6：如何解释人类数据高度相关的事实，并且每个人的行为往往与他人高度相关？一个人的数据可以提供与其有社交，专业，经济或人又统计学方面联系的其他信息。因此，个人决定分享自己的数据会影响到无数其他人。有没有很好的方法来捕捉数据共享的网络效应？这是否会影响到个人，小组和整个社区和国家的价格体系？如果社区共享隐私风险，社区是否有责任保护公民的 PI？

任务 7：考虑一个大规模的数据泄露的影响，数以百万计的人的 PI 在黑暗的网络上被盗窃并出售，作为身份盗窃环的一部分出售，或作为赎金使用。这种 PI 损失或级联事件如何影响您的模型？现在您已经有一个定价系统来量化每个人或每个损失类型的数据价值，那么机构是否有责任因 PI 的丢失或者滥用直接向个人付钱？

任务 8：根据你在这个问题上的政策建模，向决策者写一个两页的政策备忘录，介绍

效用，结果和建议。请务必指定您的建议中包含哪些类型的 PI。

您的提交应包括：

- 1) 单页汇总表
- 2) 两页备忘录
- 3) 您的解决方案不超过 20 页，最多 23 页的摘要和备忘录。
- 4) 注意：参考文献列表和任何附录不计入 23 页的限制，应在完成的解决方案后出现。

MCM 2019 Problem A: Game of Ecology

In the fictional television series Game of Thrones, based on the series of epic fantasy novels A Song of Ice and Fire[1], three dragons are raised by Daenerys Targaryen, the “Mother of Dragons.” When hatched, the dragons are small, roughly 10 kg, and after a year grow to roughly 30-40 kg. They continue to grow throughout their life depending on the conditions and amount of food available to them. For the purposes of this problem, consider these three fictional dragons are living today. Assume that the basic biology of dragons described above is accurate. You will need to make some additional assumptions about dragons that might include, for example, that dragons are able to fly great distances, breath fire, and resist tremendous trauma. As you address the problem requirements, it should be clear how your assumptions are related to the physical constraints of the functions, size, diet, changes, or other characteristics associated with the animals. Your team is assigned to analyze dragon characteristics, behavior, habits, diet, and interaction with their environment. To do so, you will have to consider many questions. At a minimum, address the following: What is the ecological impact and requirements of the dragons? What are the energy expenditures of the dragons, and what are their caloric intake requirements? How much area is required to support the three dragons? How large a community is necessary to support a dragon for varying levels of assistance that can be provided to the dragons? Be clear about what factors you are considering when addressing these questions. As with other animals that migrate, dragons might travel to different regions of the world with very different climates. How important are the climate conditions to your analysis? For example, would moving a dragon between an arid region, a warm temperate region, and an arctic region make a big difference in the resources required to maintain and grow a dragon? Once your dragon analysis is complete, draft a two-page letter to the author of A Song of Ice and Fire, George R.R. Martin, to provide guidance about how to maintain the realistic ecological underpinning of the story, especially with respect to the movement of dragons from arid regions to temperate regions and to arctic regions. While your dragon analysis does not directly apply to a real physical situation, the mathematical modeling itself makes use of many realistic features used in modeling a situation. Aside from the modeling activities themselves, describe and discuss a situation outside of the realm of fictional dragons that your modeling efforts might help inform and provide insight?

Your submission should consist of:

- One-page Summary Sheet,
- Two-page letter,

- Your solution of no more than 20 pages, for a maximum of 23 pages with your summary and letter.
- Note: Reference list and any appendices do not count toward the 23-page limit and should appear after your completed solution.

NOTE: You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Please be careful in how you use and cite the sources for your ideas and the materials used in your report.

Reference 1. Penguin Random House (2018). A Song of Ice and Fire Series. Retrieved from <https://www.penguinrandomhouse.com/series/SOO/a-song-of-ice-and-fire/>.

MCM 2019 问题-A: 生态游戏

在虚构的电视连续剧“权力的游戏”中，基于一系列史诗奇幻小说“冰与火之歌”[1]，三条龙是由“龙之母”丹妮莉丝·塔格利安（Daenerys Targaryen）养大的。当孵化时，龙是小的，大约 10 公斤，一年后长到大约 30-40 公斤。它们在整个生命过程中都会继续增长，这取决于它们的食物条件和数量。

就这个问题而言，假设这三条虚构的龙生活在今天。假设上面描述的龙的基本生物学是准确的。您将需要对龙进行一些额外的假设，例如，龙可以飞得很远，呼吸火焰，并抵御巨大的创伤。当您解决问题要求时，应该清楚您的假设如何与功能，大小，饮食，变化或与动物相关的其他特征的物理限制相关。

您的团队被分配来分析龙的特征，行为，习惯，饮食以及与环境互动。为此，您将不得不考虑许多问题。至少要解决以下问题：龙的生态影响和要求是什么？龙的能量消耗是多少，它们的热量摄入量要求是多少？支持三条龙需要多少面积？需要多大的社区（群落）来支持龙，以获得可以提供给龙的不同程度的援助？在解决这些问题时，请清楚您正在考虑哪些因素。

与其他迁徙的动物一样，龙可能会以不同的气候前往世界不同的地区。气候条件对您的分析有多重要？例如，在干旱地区，暖温带地区和北极地区之间移动龙会对维持和种植龙所需的资源产生很大影响吗？

一旦你对龙的分析完成，请写一封两页的信给“冰与火之歌”的作者 George RR Martin，以提供关于如何保持故事的现实生态基础的指导，特别是关于从干旱地区到温带地区和北极地区的龙。

虽然您对龙的分析并不直接适用于真实的物理情况，但数学建模本身会利用许多用于建模情境的实际特征。除了建模活动本身，描述和讨论虚构龙领域之外的情况，您的建模工作可能有助于提供信息并提供洞察力？

您的提交应包括：

- 一页摘要表，
- 两页的信，
- 您的解决方案不超过 20 页，最多 23 页，包含您的摘要和信函。

注意：参考列表和任何附录不计入 23 页的限制，应在完成的解决方案后显示。

注意：您不应使用未经授权的图像和使用受版权法限制的材料。请注意您如何使用和引用您的想法和报告中使用的材料的来源。

参考：

企鹅兰登书屋（2018 年）。冰与火之歌系列从这里获得

<https://www.penguinrandomhouse.com/series/SOO/a-song-of-ice-and-fire/>.

MCM 2019 Problem B: Send in the Drones: Developing an Aerial

Disaster Relief

Response System

Background: In 2017, the worst hurricane to ever hit the United States territory of Puerto Rico (see Attachment 1) left the island with severe damage and caused over 2900 fatalities. The combined destructive power of the hurricane's storm surge and wave action produced extensive damage to buildings, homes, and roads, particularly along the east and southeast coast of Puerto Rico. The storm, with its fierce winds and heavy rain, knocked down 80 percent of Puerto Rico's utility poles and all transmission lines, resulting in loss of power to essentially all of the island's 3.4 million residents. In addition, the storm damaged or destroyed the majority of the island's cellular communication networks. The electrical power and cell service outages lasted for months across much of the island, and longer in some locations. Widespread flooding blocked and damaged many highways and roads across the island, making it nearly impossible for emergency services ground vehicles to plan and navigate their routes. The full extent of the damage in Puerto Rico remained unclear for some time; dozens of areas were isolated and without communication. Demands for medical supplies, lifesaving equipment, and treatment strained health-care clinics, hospital emergency rooms, and non-governmental organizations'

(NGOs) relief operations. Demand for medical care continued to surge for some time as the chronically ill turned to hospitals and temporary shelters for care.

Problem: Non-governmental organizations (NGOs) are often challenged to provide adequate and timely response during or after natural disasters, such as the hurricane that struck the United States territory of Puerto Rico in 2017. One NGO in particular – HELP, Inc. - is attempting to improve its response capabilities by designing a transportable disaster response system called

“DroneGo.” DroneGo will use rotor wing drones to deliver pre-packaged medical supplies and provide high-resolution aerial video reconnaissance. Selected drones should be able to perform these two missions – medical supply delivery and video reconnaissance – simultaneously or separately, depending on relief conditions and scheduling. HELP, Inc. has identified various candidate rotor wing drones that it would like your team to consider for possible use in designing its DroneGo fleet (see Attachments 2, 3).

DroneGo's pre-packaged medical supplies, called medical packages, are meant to augment, not replace, the supplies provided by local medical assistance organizations on-site within the country affected by the disaster. HELP, Inc. is planning on three different medical packages referred to as MED1, MED2, and MED3. Drones will carry these medical packages within drone

cargo bays for delivery to selected locations (see Attachments 4, 5). Depending on the specific drone being used to transport medical supplies, it may be possible that multiple medical packages can be transported in a single drone cargo bay. Note that drones must land on the ground to offload medical supplies from the drone cargo bays. The video capability of the drones will provide high-resolution video of damaged and serviceable transportation road networks to HELP, Inc.'s command and control center for ground-based route planning.

HELP, Inc. will use International Standards Organization (ISO) standard dry cargo containers to quickly transport a complete DroneGo disaster response system to a particular disaster area. The individual shipping containers for all drones in the DroneGo fleet, along with all required medical packages, must fit within a maximum of three of the ISO cargo containers to be delivered to a single location, or up to three different locations if three cargo containers are used in the disaster area. Each shipping container's contents should be packed in order to minimize any need for buffer materials for unused space. Table 1 shows the dimensions of an ISO standard dry cargo container.

Table 1. Standard ISO Container Dimensions								
	Exterior			Interior			Door Opening	
	Length	Width	Height	Length	Width	Height	Width	Height
20' Standard Dry Container	20'	8'	8'6"	19'3"	7'8"	7'10"	7'8"	7'5"

HELP, Inc. is asking your team to use the 2017 situation in Puerto Rico to design a DroneGo disaster response system that will fit within the containers noted while meeting the anticipated medical supply demands during a potential similar future disaster scenario. It is possible that the demand requirements of this scenario may exceed the capabilities of the drone fleet your team identifies. If this occurs, HELP, Inc. wants to clearly understand any tradeoffs that it must make for implementing solutions to address these shortcomings.

Part 1. Develop a DroneGo disaster response system to support the Puerto Rico hurricane disaster scenario.

Consider the background information, the requirements identified in the problem statement, and the information provided in the problem attachments to address the following.

A. Recommend a drone fleet and set of medical packages for the HELP, Inc. DroneGo disaster response system that will meet the requirements of the Puerto Rico hurricane scenario. Design the associated packing configuration for each of up to three ISO cargo containers to transport the system to Puerto Rico.

B. Identify the best location or locations on Puerto Rico to position one, two, or three cargo containers of the DroneGo disaster response system to be able to conduct both medical supply delivery and video reconnaissance of road networks.

C. For each type of drone included in the DroneGo fleet:

a. Provide the drone payload packing configurations (i.e. the medical packages packed into the drone cargo bay), delivery routes and schedule to meet the identified emergency medical package requirements of the Puerto Rico hurricane scenario.

b. Provide a drone flight plan that will enable the DroneGo fleet to use onboard video

cameras to assess the major highways and roads in support of the Help, Inc. mission.

Part 2. Memo

Write a 1–2 page memo to the Chief Operating Officer (CEO) of HELP, Inc. summarizing your modeling results, conclusions, and recommendations so that she can share with her Board of Directors.

Your MCM team submission should consist of:

One-page Summary Sheet,

One- to Two-page memo to the HELP, Inc. CEO

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

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

Attachments:

1. Map of Puerto Rico
2. Potential Candidate Drones for DroneGo Fleet Consideration (with Drone payload capability)
3. Drone Cargo Bay Packing Configuration/Dimensions by Type
4. Anticipated Medical Package Demand
5. Emergency Medical Package Configuration/Dimensions

Attachment 1: Map of Puerto Rico



Attachment 2: Potential Candidate Drones for DroneGo Fleet Consideration (with Drone Payload Capability)

	Shipping Container Dimensions			Performance Characteristics/Capabilities			Configurations Capabilities		
Drone	Length (in.)	Width (in.)	Height (in.)	Max Payload Capability (lbs.)	Speed (km/h)	Flight Time No Cargo (min)	Video Capable	Medical Package Capable	Drone Cargo Bay Type*
A	45	45	25	3.5	40	35	Y	Y	1
B	30	30	22	8	79	40	Y	Y	1
C	60	50	30	14	64	35	Y	Y	2
D	25	20	25	11	60	18	Y	Y	1
E	25	20	27	15	60	15	Y	Y	2
F	40	40	25	22	79	24	N	Y	2
G	32	32	17	20	64	16	Y	Y	2
H Tethered	65	75	41	N/A	N/A	Indefinite	N	N	N/A

*Note that cargo bays are affixed to the drone and that drone must be on the ground to offload cargo. See Attachment 3 for Drone Cargo Bay Type Configuration/Dimensions.

Attachment 3: Drone Cargo Bay Packing Configuration/Dimensions by Type

Drone Cargo Bay Type	Length (in)	Width (in)	Height (in)	
1	8	10	14	Top Loaded
2	24	20	20	Top Loaded

Attachment 4: Anticipated Medical Package Demand

Delivery Location			Emergency Medical Packages **		
Location Name	Latitude	Longitude	Requirement	Quantity	Frequency
Caribbean Medical Center Jajardo	18.33	-65.65	MED 1	1	Daily
			MED 3	1	Daily
Hospital HIMA San Pablo	18.22	-66.03	MED 1	2	Daily
			MED 3	1	Daily
Hospital Pavia Santurce San Juan	18.44	-66.07	MED 1	1	Daily
			MED 2	1	Daily
Puerto Rico Children's Hospital Bayamon	18.40	-66.16	MED 1	2	Daily
			MED 2	1	Daily
			MED 3	2	Daily
Hospital Pavia Arecibo Arecibo	18.47	-66.73	MED 1	1	Daily

**See Attachment 5 for Emergency Medical Packages 1, 2, and 3 Configurations/Dimensions.

Attachment 5: Emergency Medical Package Configuration/Dimensions

Emergency Medical Package Configuration		
Package ID	Weight (lbs.)	Package Dimensions (in.) (L × W × H)
MED 1	2	14 × 7 × 5
MED 2	2	5 × 8 × 5
MED 3	3	12 × 7 × 4

Glossary:

Cargo Container (Shipping Container): a large rectangular container with doors on the ends for loading and packing, and made of material suitable for shipping, storing, and handling in many weather and climate conditions.

Drone (Unmanned Aerial Vehicle, UAV): a flying robot that can be remotely controlled or fly autonomously through software-controlled flight plans in their embedded systems that work in conjunction with onboard sensors and GPS.

Drone Cargo Bay: For rotor wing drones, this is an externally carried “box” used to transport materials. For this problem, the drones under consideration have one of two types (sizes) of cargo bays. Note that each drone must land for the medical packages to be unloaded from the bay at its destination.

Drone Fleet: a set of drones for a particular mission or purpose. For this problem, the total set of drones by type (A to H) and Payload Capability (Visual and Medical) needed to meet the requirements of HELP, Inc.

Drone Payload Packing Configuration: how the drone payload bays are packed. For this problem, how the medical packages being transported by a drone are packed inside the drone cargo bay.

Medical Package: a predetermined set of medical supplies packed in a single container. For this problem, there are three Medical Package Configurations (MED1, MED2, MED3) available for transport by a drone from a deployed cargo container location to the demand location.

Non-governmental Organization (NGO): Usually non-profit and sometimes international organization independent of government and governmental organizations that is active in humanitarian, educational, healthcare, social, public policy, human rights, environmental and other areas in attempts to affect change.

Payload Capability: the carrying capacity of an aircraft or launch vehicle, usually measured in terms of weight. For this problem, the capability/capacity of the drone to carry medical packages.

MCM 2019 问题-B: 发送无人机: 开发空中灾难救援响应系统

背景: 2017 年, 有史以来最严重的飓风袭击了波多黎各的美国领土 (见附件 1) 使该岛遭受严重破坏, 造成 2900 多人死亡。该飓风风暴潮和波浪作用的综合破坏力对建筑物, 房屋和道路产生了广泛的破坏, 特别是在波多黎各东部和东南沿海地区。风暴和暴雨带来的风

暴击倒了波多黎各 80% 的电线杆和所有输电线路，导致岛上 340 万居民基本丧失了电力。此外，风暴还破坏或摧毁了岛上大部分的蜂窝通信网络。岛上大部分地区的电力和电池服务中断持续数月，而在某些地区则更长。广泛的洪水阻塞并破坏了岛上的许多高速公路和道路，使得紧急服务地面车辆几乎不可能规划和导航他们的路线。波多黎各的全面破坏程度在一段时间内仍不明朗；数十个地区被孤立，没有沟通。对医疗用品，救生设备和治疗紧张的保健诊所，医院急诊室和非政府组织（NGO）救济行动的需求。由于长期病患转向医院和临时住所接受护理，医疗保健需求持续激增一段时间。

问题：非政府组织（NGO）经常被要求提供足够的资金

在自然灾害期间或之后及时作出反应，例如 2017 年袭击美国波多黎各领土的飓风。特别是一个非政府组织 - HELP, Inc. - 试图通过设计一个名为可移动的灾害应对系统来提高其应对能力。“DroneGo。” DroneGo 将使用旋翼无人机提供预先包装的医疗用品，并提供高分辨率航拍视频侦察。选定的无人机应该能够同时或单独执行这两项任务 - 医疗供应和视频侦察 - 取决于救援条件和时间安排。HELP, Inc. 已经确定了各种候选转子翼无人机，希望您的团队考虑将其用于设计其 DroneGo 车队（见附件 2,3）。

DroneGo 的预包装医疗用品，称为医疗包，旨在增加而不是取代受灾害影响的国家内现场医疗援助组织提供的用品。HELP, Inc. 计划推出三种不同的医疗包，称为 MED1, MED2 和 MED3。无人机将在无人机货舱内携带这些医疗包裹，以便运送到选定的地点（见附件 4,5）。根据用于运输医疗用品的特定无人机，可能可以在单个无人机货舱中运输多个医疗包。请注意，无人机必须降落在地面上以从无人机货舱卸载医疗用品。无人机的视频功能将为 HELP, Inc. 的地面路线规划指挥和控制中心提供损坏和可维修的交通道路网络的高分辨率视频。

HELP, Inc. 将使用国际标准组织（ISO）标准干货集装箱快速将完整的 DroneGo 灾难响应系统运输到特定的灾区。DroneGo 船队中所有无人机的个别运输容器以及所有必需的医疗包装必须最多容纳三个 ISO 货物集装箱才能运送到一个地点，如果三个货物集装箱是三个不同的位置，则最多可以容纳三个不同的地点。用于灾区。应包装每个运输容器的内容，以便最大限度地减少对未使用空间的缓冲材料的需求。表 1 显示了 ISO 标准干货集装箱的尺寸。

Table 1. Standard ISO Container Dimensions								
	Exterior			Interior			Door Opening	
	Length	Width	Height	Length	Width	Height	Width	Height
20' Standard Dry Container	20'	8'	8'6"	19'3"	7'8"	7' 10"	7'8"	7'5"

HELP, Inc. 要求您的团队使用 2017 年在波多黎各的情况来设计 DroneGo 灾害响应系统，适合在满足预期的容器内潜在的类似未来灾难情景期间的医疗供应需求。此方案的需求可能超出您的团队识别的无人机机队的能力。如果发生这种情况，HELP, Inc. 希望清楚地理解为实现解决这些缺点的解决方案必须做出的任何权衡。

第 1 部分。开发 DroneGo 灾难响应系统，以支持波多黎各飓风灾难情景。

请考虑背景信息，问题陈述中确定的要求以及问题附件中提供的信息，以解决以下问题。

A. 为 HELP, Inc. DroneGo 推荐无人机机队和一套医疗包灾害应对系统将满足波多黎各飓风的要求场景。为最多三个 ISO 货物设计相关的包装配置将系统运往波多黎各的集装箱。

B.确定波多黎各最佳位置或位置，以定位一个，两个或三个货物 DroneGo 灾难响应系统的容器能够同时进行医疗道路网络的供应和视频侦察。

C.对于 DroneGo 舰队中包含的每种类型的无人机：一个。提供无人机有效载荷包装配置（即医疗包装）装入无人机货舱，送货路线和时间表，以满足确定波多黎各飓风情景的紧急医疗包要求。

湾提供无人机飞行计划，使 DroneGo 车队能够在机上使用用于评估主要公路和道路的摄像机，以支持 Help, Inc 任务。

第 2 部分。备忘录

写一份 1-2 页的备忘录给 HELP, Inc. 的首席运营官（CEO）。总结你的建模结果，结论和建议，以便她可以与她的董事会分享

您的 MCM 团队提交应包括：

单页摘要表，

HELP, Inc. 首席执行官的一到两页备忘录

您的解决方案不超过 20 页，最多 23 页，包括您的摘要和备忘录。

注意：参考列表和任何附录不计入 23 页的限制，应在完成的解决方案后显示。

附件：

1. 波多黎各地图



2. 针对 DroneGo 舰队考虑的潜在候选无人机（具有无人机有效载荷能力）

Drone	Shipping Container Dimensions			Performance Characteristics/Capabilities			Configurations Capabilities		
	Length (in.)	Width (in.)	Height (in.)	Max Payload Capability (lbs.)	Speed (km/h)	Flight Time No Cargo (min)	Video Capable	Medical Package Capable	Drone Cargo Bay Type*
A	45	45	25	3.5	40	35	Y	Y	1
B	30	30	22	8	79	40	Y	Y	1
C	60	50	30	14	64	35	Y	Y	2
D	25	20	25	11	60	18	Y	Y	1
E	25	20	27	15	60	15	Y	Y	2
F	40	40	25	22	79	24	N	Y	2
G	32	32	17	20	64	16	Y	Y	2
H Tethered	65	75	41	N/A	N/A	Indefinite	N	N	N/A

*Note that cargo bays are affixed to the drone and that drone must be on the ground to offload cargo. See Attachment 3 for Drone Cargo Bay Type Configuration/Dimensions.

3. 无人机货物海湾包装配置/尺寸

Attachment 3: Drone Cargo Bay Packing Configuration/Dimensions by Type

Drone Cargo Bay Type	Length (in)	Width (in)	Height (in)	
1	8	10	14	Top Loaded
2	24	20	20	Top Loaded

4. 预期的医疗包装需求

Attachment 4: Anticipated Medical Package Demand

Delivery Location			Emergency Medical Packages **		
Location Name	Latitude	Longitude	Requirement	Quantity	Frequency
Caribbean Medical Center Jajardo	18.33	-65.65	MED 1	1	Daily
			MED 3	1	Daily
Hospital HIMA San Pablo	18.22	-66.03	MED 1	2	Daily
			MED 3	1	Daily
Hospital Pavia Santurce San Juan	18.44	-66.07	MED 1	1	Daily
			MED 2	1	Daily
Puerto Rico Children's Hospital Bayamon	18.40	-66.16	MED 1	2	Daily
			MED 2	1	Daily
			MED 3	2	Daily
Hospital Pavia Arecibo Arecibo	18.47	-66.73	MED 1	1	Daily

**See Attachment 5 for Emergency Medical Packages 1, 2, and 3 Configurations/Dimensions.

5. 紧急医疗包配置/尺寸

Attachment 5: Emergency Medical Package Configuration/Dimensions

Emergency Medical Package Configuration		
Package ID	Weight (lbs.)	Package Dimensions (in.) (L × W × H)
MED 1	2	14 × 7 × 5
MED 2	2	5 × 8 × 5
MED 3	3	12 × 7 × 4

MCM 2019 Problem C: The Opioid Crisis

Background: The United States is experiencing a national crisis regarding the use of synthetic and non-synthetic opioids, either for the treatment and management of pain (legal, prescription use) or for recreational purposes (illegal, non-prescription use). Federal organizations such as the Centers for Disease Control (CDC) are struggling to “save lives and prevent negative health effects of this epidemic, such as opioid use disorder, hepatitis, and HIV infections, and neonatal abstinence syndrome.”¹ Simply enforcing existing laws is a complex challenge for the Federal Bureau of Investigation (FBI), and the U.S. Drug Enforcement Administration (DEA), among others.

There are implications for important sectors of the U.S. economy as well. For example, if the opioid crisis spreads to all cross-sections of the U.S. population (including the college-educated and those with advanced degrees), businesses requiring precision labor skills, high technology component assembly, and sensitive trust or security relationships with clients and customers might have difficulty filling these positions. Further, if the percentage of people with opioid addiction increases within the elderly, health care costs and assisted living facility staffing will also be affected.

The DEA/National Forensic Laboratory Information System (NFLIS), as part of the Drug Enforcement Administration's (DEA) Office of Diversion Control, publishes a data-heavy annual report addressing

"drug identification results and associated information from drug cases analyzed by federal, state, and local forensic laboratories." The database within NFLIS includes data from crime laboratories that handle over 88% of the nation's estimated 1.2 million annual state and local drug cases. For this problem, we focus on the individual counties located in five (5) U.S. states: Ohio, Kentucky, West Virginia, Virginia, and Tennessee. In the U.S., a county is the next lower level of government below each state that has taxation authority.

Supplied with this problem description are several data sets for your use. The first file

(MCM_NFLIS_Data.xlsx) contains drug identification counts in years 2010-2017 for narcotic analgesics (synthetic opioids) and heroin in each of the counties from these five states as reported to the DEA by crime laboratories throughout each state. A drug identification occurs when evidence is submitted to crime laboratories by law enforcement agencies as part of a

criminal investigation and the laboratory's forensic scientists test the evidence. Typically, when law enforcement organizations submit these samples, they provide location data (county) with their incident reports. When evidence is submitted to a crime laboratory and this location data is not provided, the crime laboratory uses the location of the city/county/state investigating law enforcement organization that submitted the case. For the purposes of this problem, you may assume that the county location data are correct as provided.

The additional seven (7) files are zipped folders containing extracts from the U.S. Census Bureau that represent a common set of socio-economic factors collected for the counties of these five states during each of the years 2010-2016 (ACS_xx_5YR_DP02.zip). (Note: The same data were not available for 2017.)

A code sheet is present with each data set that defines each of the variables noted. While you may use other resources for research and background information, **THE DATA SETS PROVIDED CONTAIN THE ONLY DATA YOU SHOULD USE FOR THIS PROBLEM.**

Problem:

Part 1. Using the NFLIS data provided, build a mathematical model to describe the spread and characteristics of the reported synthetic opioid and heroin incidents (cases) in and between the five states and their counties over time. Using your model, identify any possible locations where specific opioid use might have started in each of the five states.

If the patterns and characteristics your team identified continue, are there any specific concerns the U.S. government should have? At what drug identification threshold levels do these occur? Where and when does your model predict they will occur in the future?

Part 2. Using the U.S. Census socio-economic data provided, address the following questions:

There are a good number of competing hypotheses that have been offered as explanations as to how opioid use got to its current level, who is using/abusing it, what contributes to the growth in opioid use and addiction, and why opioid use persists despite its known dangers. Is use or trends-in-use somehow associated with any of the U.S. Census socio-economic data provided? If so, modify your model from Part 1 to include any important factors from this data set.

Part 3. Finally, using a combination of your Part 1 and Part 2 results, identify a possible strategy for countering the opioid crisis. Use your model(s) to test the effectiveness of this strategy; identifying any significant parameter bounds that success (or failure) is dependent upon.

In addition to your main report, include a 1-2 page memo to the Chief Administrator, DEA/NFLIS Database summarizing any significant insights or results you identified during this modeling effort.

Your submission should consist of:

One-page Summary Sheet,

One- to Two-page memo,

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

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

Attachments:

2019_MCMPProblemC_DATA.zip - Includes seven zip folders and the NFLIS_Data file.

ACS_10_5YR_DP02.zip

ACS_12_5YR_DP02.zip

ACS_14_5YR_DP02.zip

ACS_16_5YR_DP02.zip

ACS_11_5YR_DP02.zip

ACS_13_5YR_DP02.zip

ACS_15_5YR_DP02.zip

MCM_NFLIS_Data.xlsx

Glossary:

analgesic – pain relieving medication

county – (in the U.S.) an administrative or political subdivision of a state; a region having specific boundaries and some level of governmental authority.

heroin – an illegal, euphoria producing, highly addictive analgesic drug processed from morphine (a naturally occurring substance extracted from the seed pods of certain varieties of poppy plants).

non-synthetic opioids – a class of drugs made from extracting chemicals in opium leaves, e.g. morphine, codeine, heroin.

opioids – pain relieving drugs that are often highly addictive

socio-economic factors – factors within a society that describe the relationship between social and economic status and class such as education, income, occupation, and employment.

synthetic opioid – man-made opioids

MCM 2019 问题-C: 阿片类药物危机

背景:美国正在经历一场关于使用合成和非合成阿片类药物治疗和管理疼痛(合法、处方使用)或用于娱乐用途(非法、非处方使用)的全国性危机。美国疾病控制中心(CDC)等联邦机构正在努力“拯救生命,防止这一流行病对健康造成的负面影响,例如阿片类药物使用障碍,肝炎, HIV 感染,新生儿节欲综合症。”对于联邦调查局(FBI)和美国药品管理局,执法局(DEA)等来说,仅仅是执行现有法律都是一个复杂的挑战。

这对美国经济的重要领域也有影响。例如,如果阿片类药物危机蔓延到美国人口的各个阶层(包括受过大学教育和更高级学位的人群),那些需要精确劳动技能、高技术组建组装以及与客户和客户之间的敏感信任或安全关系的企业可能很难找到工人来完成相关工作。此外,如果老年人中阿片类药物成瘾者的比例增加,保健费用和辅助生活设施的工作人员也将受到影响。

DEA/国家法医实验室信息系统(NFLIS)是美国药品监督管理局(DEA)转用管制办公室的一部分,它发布了一份涉及大量数据的年度报告“从联邦,州,和当地的法医实验室分析药物案件的药物鉴定结果和相关信息。”NFLIS 的数据库包括来自犯罪实验室的数据,这些数据处理了美国估计每年 120 万州和地方毒品案件中的 88%以上。对于这个问题,我们关注美国五个州的县:俄亥俄州、肯塔基州、西弗吉尼亚州、弗吉尼亚州和田纳西州。在美国一个县是下一个级别的政府低于每个州,有自己的税务机关。

这个问题描述提供了几个供您使用的数据集。第一个文件(MCM_NFLIS_Data.xlsx)包含 2010-2017 年这五个州的犯罪实验室向 DEA 报告的各县的麻醉性镇痛药(合成阿片类药物)和海洛因的药物识别计数。当证据被提交给犯罪实验室由执法机构作为刑事调查的一部分,实验室的法医对证据进行检验。通常,当执法机构提交这些文件时样本,他们提供事件的位置数据(县)与他们的事件报告。当证据被提交给犯罪实验室而该位置数据未被提供时,犯罪实验室使用市/县/州调查立案执法机构的位置作为数据。对于这个问题,您可以假设所提供的县位置数据是正确的。

另外七(7)个文件是压缩文件夹, 其中包含美国人口普查局(U.S. Census Bureau)的数据, 这些数据代表了 2010-2016 年这五个州的县(ACS_xx_5YR_DP02.zip)每年收集的一组社会经济因素。(注:没有相同的数据 2017 年)。每个数据集都有一个代码表, 其中定义了注意到的每个变量。虽然您可以使用其他资源来研究和获取背景信息, 但是提供的数据集只包含您应该用于解决此问题的数据。

问题:

第 1 部分: 利用 NFLIS 提供的数据, 建立一个数学模型来描述药物使用扩散和 5 个州及其县之间报告的合成阿片类药物和海洛因事件(案件)的特点。使用您的模型, 确定特定阿片类药物在每个州里最先开始使用是在哪里(五个州分别考虑)。如果您的团队确定的模式和特征持续下去, 美国政府是否应该有什么特别的担忧?这些在什么药物鉴定阈值水平发生?您的模型预测它们将在哪里以及何时发生?

第 2 部分: 利用美国人口普查提供的社会经济数据, 解决以下问题:

有很多相互矛盾的假设, 它们被用来解释阿片类药物的使用如何达到了目前的水平, 谁在使用/滥用它, 是什么导致了阿片类药物使用和成瘾的增长, 以及为什么尽管已知的危险阿片类药物使用仍然持续。使用药物或使用的趋势在某种程度上与美国人口普查提供的社会经济数据有关吗?如果是这样, 请修改第 1 部分中的模型, 以包含此数据集中的任何重要因素。

第 3 部分: 最后, 结合第 1 部分和第 2 部分的结果, 确定可能的策略应对阿片类药物危机。使用您的模型来测试此策略的有效性;确定成功(或失败)所依赖的任何重要参数界限。

除了你的主要报告, 还包括一到两页的备忘录给首席管理员和 DEA/NFLIS 数据库, 总结你在建模过程中发现的任何重要见解或结果。

您的提交应包括:

- 单页摘要表
- 一到两页的备忘录
- 您的解决方案不超过 20 页, 最多 23 页与您的摘要和备忘录
- 注意: 参考列表和任何附录不计入 23 页的限制和应在完成的解决方案后出现

附件:

2019_mcmproblemc_data 。 zip — 包括七个 zip 文件夹和 NFLIS_Data 文件。

ACS_10_5YR_DP02.zip	ACS_12_5YR_DP02.zip	ACS_14_5YR_DP02.zip
ACS_16_5YR_DP02.zip	ACS_11_5YR_DP02.zip	ACS_13_5YR_DP02.zip
ACS_15_5YR_DP02.zip	MCM_NFLIS_Data.xlsx	

名词解释:

镇痛药 - 缓解疼痛的药物

县 - (在美国) 国家的行政或政治分支; 一个地区具有特定的界限和某种程度的政府权威。

海洛因 - 一种非法, 兴奋, 产生高度上瘾的止痛药吗啡(一种从某些种子荚中提取的天然物质)各种罂粟植物)。

非合成阿片类药物 - 一种从鸦片中提取化学物质制成的药物 叶子, 例如 吗啡, 可待因, 海洛因。

阿片类药物 - 缓解药物往往很容易上瘾

社会经济因素 - 社会中描述两者之间关系的因素社会经济地位和阶级, 如教育, 收入, 职业和就业机会。

合成阿片类药物 - 人造阿片类药物

ICM 2019 Problem D: Time to leave the Louvre

The increasing number of terror attacks in France[1] requires a review of the emergency evacuation plans at many popular destinations. Your ICM team is helping to design evacuation plans at the Louvre in Paris, France. In general, the goal of evacuation is to have all occupants leave the building as quickly and safely as possible. Upon notification of a required evacuation, individuals egress to and through an optimal exit in order to empty the building as quickly as possible.

The Louvre is one of the world's largest and most visited art museum, receiving more than 8.1 million visitors in 2017[2]. The number of guests in the museum varies throughout the day and year, which provides challenges in planning for regular movement within the museum. The diversity of visitors -- speaking a variety of languages, groups traveling together, and disabled visitors -- makes evacuation in an emergency even more challenging.

The Louvre has five floors, two of which are underground.

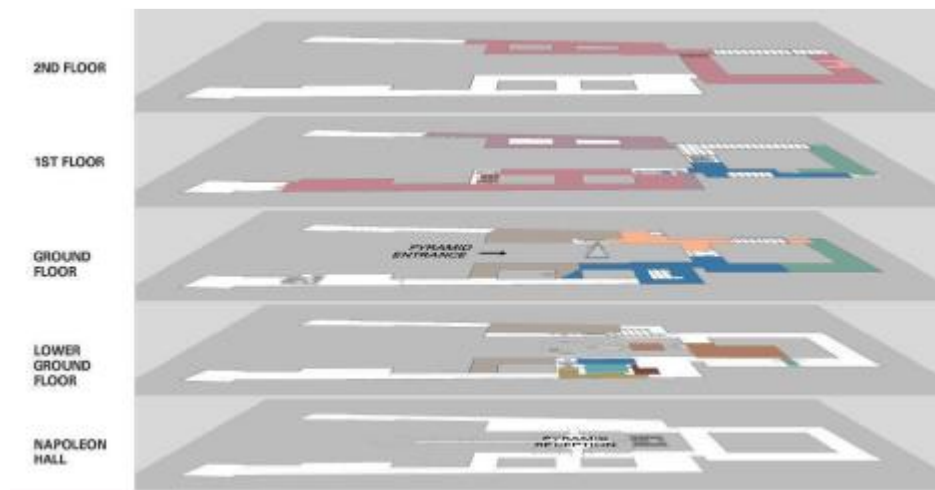


Figure 1: Floor plan of Louvre[3]

The 380,000 exhibits located on these five floors cover approximately 72,735 square meters, with building wings as long as 480 meters or 5 city blocks[3]. The pyramid entrance is the main and most used public entrance to the museum. However, there are also three other entrances usually reserved for groups and individuals with museum memberships: the Passage Richelieu entrance, the Carrousel du Louvre entrance, and the Portes Des Lions entrance. The Louvre has an online application, “Affluences” (<https://www.affluences.com/louvre.php>), that provides real-time updates on the estimated waiting time at each of these entrances to help facilitate entry to the museum. Your team might consider how technology, to include apps such as Affluences, or others could be used to facilitate your evacuation plan.

Only emergency personnel and museum officials know the actual number of total available exit points (service doors, employee entrances, VIP entrances, emergency exits, and old secret entrances built by the monarchy, etc.). While public awareness of these exit points could provide additional strength to an evacuation plan, their use would simultaneously cause security concerns due to the lower or limited security postures at these exits compared with level of security at the four main entrances. Thus, when creating your model, your team should consider carefully when and how any additional exits might be utilized.

Your supervisor wants your ICM team to develop an emergency evacuation model that allows the museum leaders to explore a range of options to evacuate visitors from the museum, while also allowing emergency personnel to enter the building as quickly as possible. It is important to identify potential bottlenecks that may limit movement towards the exits. The museum emergency planners are especially interested in an adaptable model that can be designed to address a broad set of considerations and various types of potential threats. Each threat has the potential to alter or remove segments of possible routes to safety that may be essential in a single optimized route. Once developed, validate your model(s) and discuss how the Louvre would implement it.

Based on the results of your work, propose policy and procedural recommendations for emergency management of the Louvre. Include any applicable crowd management and control procedures that your team believes are necessary for the safety of the visitors. Additionally, discuss how you could adapt and implement your model(s) for other large, crowded structures.

Your submission should consist of:

One-page Summary Sheet,

Your solution of no more than 20 pages, for a maximum of 21 pages with your summary.

Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.

Note: Reference list and any appendices do not count toward the 21-page limit and should appear after your completed solution.

References:

[1] Reporters, Telegraph. “Terror Attacks in France: From Toulouse to the Louvre.” The Telegraph, Telegraph Media Group, 24 June 2018, www.telegraph.co.uk/news/0/terror-attacks-france-toulouse-louvre/.

[2] “8.1 Million Visitors to the Louvre in 2017.” Louvre Press Release, 25 Jan. 2018, presse.louvre.fr/8-1-million-visitors-to-the-louvre-in-2017/.

[3] “Interactive Floor Plans.” Louvre - Interactive Floor Plans | Louvre Museum | Paris, 30 June 2016, www.louvre.fr/en/plan.

[4] “Pyramid” Project Launch – The Musée du Louvre is improving visitor reception (2014-2016).” Louvre Press Kit, 18 Sept. 2014, www.louvre.fr/sites/default/files/dp_pyramide%2028102014_en.pdf.

[5] “The ‘Pyramid’ Project - Improving Visitor Reception (2014-2016).” Louvre Press Release, 6 July 2016, presse.louvre.fr/the-pyramid-project/.

Glossary:

Bottlenecks – places where movement is dramatically slowed or even stopped.

Emergency personnel – people who help in an emergency, such as guards, fire fighters, medics, ambulance crews, doctors, and police.

ICM 2019 问题-D: 离开卢浮宫的时间

法国越来越多的恐怖袭击导致需要审查许多热门目的地的紧急疏散计划。您的 ICM 团队正在帮助设计法国巴黎卢浮宫的疏散计划。一般来说，疏散的目标是让所有的居住者尽可

能快和安全地离开大楼。一旦通知需要疏散，人员进出最佳出口，以便尽快清空建筑物。

卢浮宫是世界上最大、参观次数最多的艺术博物馆之一，2017 年接待游客超过 810 万人次。博物馆内的客人数量在一年一天中各不相同，这在计划博物馆内的定期活动方面提出了挑战。游客的多样性——说各种语言、结伴旅行的团体和残疾游客——使得紧急情况下的疏散变得更具挑战性。

卢浮宫有五层，其中两层在地下。

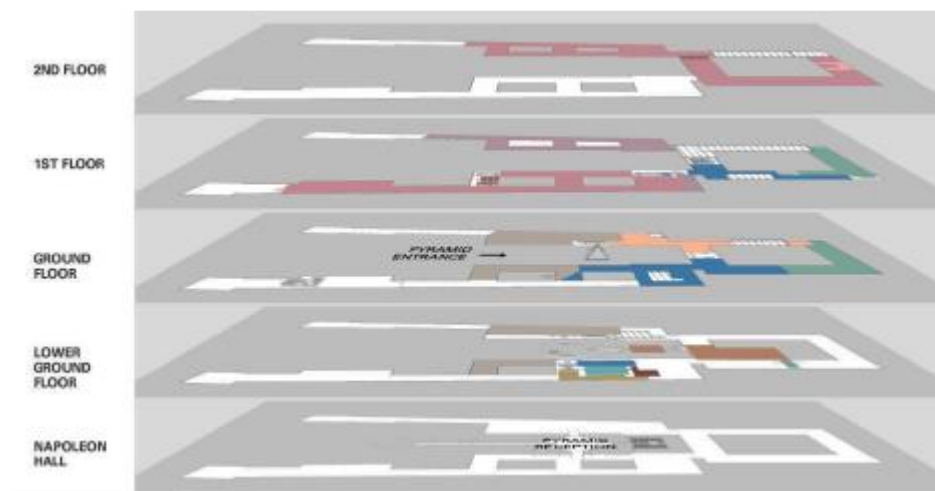


图 1：卢浮宫平面布置图

位于这五层的 38 万件展品，占地约 72735 平方米，建筑面积达 480 米或 5 个城市街区。金字塔入口是博物馆的主要和最常用的公共入口。然而，还有另外三个入口通常是具有博物馆会员资格的团体和个人保留的：通道黎塞留入口、卢浮宫卡鲁塞尔入口和狮子门入口。卢浮宫有一个在线应用程序“Affluences”。您的团队可以考虑如何使用技术，包括应用程序（如流言）或其他应用程序来加强您的疏散计划。网址：<https://www.affluences.com/louvre.php>

只有应急人员和博物馆官员才知道实际可用的出口点总数（服务门、员工入口、VIP 入口、紧急出口和君主制建造的旧秘密入口等）。虽然公众对这些出口点的认识可以为疏散计划提供额外的力量，但与四个主要入口的安全水平相比，这些出口的安全指示牌有限，因此使用这些出口点会同时引发安全问题。因此，在创建模型时，您的团队应该仔细考虑何时以及如何使用任何其他出口。

您的主管希望您的 ICM 团队开发一种紧急疏散模型，允许博物馆领导尝试各种方法以疏散博物馆的游客，同时也允许紧急人员尽快进入大楼。识别可能限制疏散的潜在瓶颈非常重要。博物馆的应急规划人员尤其对适应性很强的模型感兴趣，如果这种模型可以设计来考虑很多因素和各种类型的潜在威胁。每种威胁都有可能改变或移除在单一优化路线中可以通行的路段。一旦开发出来，验证您的模型并讨论卢浮宫将如何实现它。

根据您的工作成果，提出您的团队认为对访客安全的卢浮宫应急管理的政策和程序建议。包括任何适用的人群管理和控制程序。另外，讨论如何为其他大型、拥挤的结构调整 and 实现模型。

您的提交应包括：

一页摘要表，

您的解决方案不超过 20 页，最多 21 页和您的摘要。

●法官希望有一份完整的参考文献列表，并在文本中引用，但在评判过程中可能不考虑附录。

●注意:参考列表和任何附录不计入 21 页的限制,应在完成解决方案后出现。

参考文献:

- (1) 记者,电报。“法国的恐怖袭击:从图卢兹到卢浮宫。”《每日电讯报》,电报媒体集团,2018年6月24日。
www.telegraph.co.uk/news/0/terrorattacks-france-toulouse-louvre/.
- (2) “2017 年有 810 万游客来到卢浮宫”,卢浮宫新闻稿,2018 年 1 月 25 日。
presse.louvre.fr/8-1-million-visitors-to-the-louvre-in-2017/.
- (3) “互动楼层平面图。”卢浮宫-互动楼层平面图卢浮宫博物馆巴黎,2016 年 6 月 30 日,。网址: www.louvre.fr/en/plan.
- (4) “金字塔”项目启动——卢浮宫博物馆正在改善游客接待。(2014-2016 年)。
“卢浮宫新闻工具包,2014 年 9 月 18 日。
www.louvre.fr/sites/default/files/dp_pyramide%2028102014_en.pdf.
- (5) “金字塔项目-改善游客接待(2014-2016 年)。”卢浮宫新闻稿,2016 年 7 月 6 日,。
presse.louvre.fr/the-pyramid-project/

名称解释:

瓶颈 - 人群移动速度显著减慢甚至停止的地方。

应急人员 - 在紧急情况下提供帮助的人员,如警卫、消防队员、医护人员、救护人员、医生和警察。

ICM 2019 Problem E: What is the Cost of Environmental Degradation?

Economic theory often disregards the impact of its decisions on the biosphere or assumes unlimited resources or capacity for its needs. There is a flaw in this viewpoint, and the environment is now facing the consequences. The biosphere provides many natural processes to maintain a healthy and sustainable environment for human life, which are known as ecosystem services. Examples include turning waste into food, water filtration, growing food, pollinating plants, and converting carbon dioxide into oxygen. However, whenever humans alter the ecosystem, we potentially limit or remove ecosystem services. The impact of local small-scale changes in land use, such as building a few roads, sewers, bridges, houses, or factories may seem negligible. Add to these small projects, large-scale projects such as building or relocating a large corporate headquarters, building a pipeline across the country, or expanding or altering waterways for extended commercial use. Now think about the impact of many of these projects across a region, country, and the world. While individually these activities may seem inconsequential to the total ability of the biosphere's functioning potential, cumulatively they are directly impacting the biodiversity and causing environmental degradation.

Traditionally, most land use projects do not consider the impact of, or account for changes to, ecosystem services. The economic costs to mitigate negative results of land use changes: polluted rivers, poor air quality, hazardous waste sites, poorly treated waste water, climate changes, etc.,

are often not included in the plan. Is it possible to put a value on the environmental cost of land use development projects? How would environmental degradation be accounted for in these project costs? Once ecosystem services are accounted for in the cost-benefit ratio of a project, then the true and comprehensive valuation of the project can be determined and assessed.

Your ICM team has been hired to create an ecological services valuation model to understand the true economic costs of land use projects when ecosystem services are considered. Use your model to perform a cost benefit analysis of land use development projects of varying sizes, from small community-based projects to large national projects. Evaluate the effectiveness of your model based on your analyses and model design. What are the implications of your modeling on land use project planners and managers? How might your model need to change over time?

Your submission should consist of:

One-page Summary Sheet,

Your solution of no more than 20 pages, for a maximum of 21 pages with your summary.

Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.

Note: Reference list and any appendices do not count toward the 21-page limit and should appear after your completed solution.

References:

Chee, Y., 2004. An ecological perspective on the valuation of ecosystem services. *Biological Conservation* 120, 549-565.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. *Nature* 387, 253– 260.

Gómez-Baggethuna, E., de Groot, R., Lomas, P., Montesa, C., 1 April 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics* 69 (6), 1209-1218.

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Richmond, A., Kaufmann R., Myneni, R., 2007, Valuing ecosystem services: A shadow price for net primary production. *Ecological Economics* 64, 454-462.

Yang, Q., Liu, G., Casazza, M., Campbell, E., Giannettia, B., Brown, M., December 2018. Development of a new framework for non-monetary accounting on ecosystem services valuation. *Ecosystem Services* 34A, 37-54.

Data sources:

US based data: <https://www.data.gov/ecosystems/>

Satellite data:

<https://www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets>

Glossary:

Biodiversity - refers to the variety of life in an ecosystem; all of the living organisms within a given area.

Biosphere - the part of the Earth that is occupied by living organisms and generally includes the interaction between these organisms and their physical environment.

Ecosystem - a subset of the biosphere that primarily focuses on the interaction between living

things and their physical environment.

Ecosystem Services – the many benefits and assets that humans receive freely from our natural environment and a fully functioning ecosystem.

Environmental Degradation – the deterioration or compromise of the natural environment through consumption of assets either by natural processes or human activities.

Mitigate – to make less severe, painful, or impactful.

Valuation - refers to the estimating or determining the current worth of something.

ICM 2019 问题-E：环境退化的代价是什么？

经济理论经常忽视其决策对生物圈的影响，或者为其需求承担无限的资源或能力。这种观点存在缺陷，现在环境面临着后果。生物圈供了许多自然过程来维持健康和可持续的人类生活环境，这被称为生态系统服务。例如包括将废物变成食物，水过滤，种植食物，授粉植物，以及将二氧化碳转化为氧气。然而，每当人类改变生态系统时，我们可能会限制或消除生态系统服务。当地小规模：土地利用变化的影响，例如建设一些道路，下水道，桥梁，房屋或工厂，可能看起来微不足道。加入这些小型项目，大型项目，如建设或搬迁大型公司总部，

在全国范围内建设管道，或扩大或改变水道以扩展商业用途。现在考虑一下这个地区，国家和世界上许多这些项目的影响。虽然这些活动可能对生物圈的总体运作能力无关紧要，但日积月累的看，它们直接影响生物多样性并导致环境退化。

传统上，大多数土地利用项目都没有考虑生态系统服务的影响或考虑到变化。减轻土地利用变化负面结果的经济成本：污染的河流，空气质量差，危险废物场所，处理不当的废水，气候变化等，往往不包括在计划中。是否有可能对土地利用开发项目的环境成本进行评估？

如何在这些项目成本中考虑环境退化？一旦将生态系统服务计入项目的成本效益比，就可以确定和评估项目的真实和全面估值。

您的 ICM 团队已被聘请创建生态服务评估模型，以了解考虑生态系统服务时土地利用项目的真实经济成本。使用您的模型对不同规模的土地利用开发项目进行成本效益分析，从小型社区项目到大型

国家项目。根据您的分析和模型设计评估模型的有效性。您的建模对土地使用项目规划人员和管理人员有何影响？您的模型如何随时间变化？

您的提交应包括：

- 单页摘要表
- 您的解决方案不超过 20 页，最多 21 页与您的摘要
- 法官期望 提供完整的参考文献列表，其中包含文本引用，但在评审过程中可能不会考虑附录
- 注意：参考列表和任何附录不计入 21 页限制，应在完成解决方案后显示

参考文献

Chee, Y., 2004. An ecological perspective on the valuation of ecosystem services. *Biological Conservation* 120, 549-565.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. *Nature* 387, 253– 260.

Gómez-Baggethuna, E., de Groot, R., Lomas, P., Montesa, C., 1 April 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. *Ecological Economics* 69 (6), 1209-1218.

Norgaard, R., 1 April 2010. Ecosystem services: From eye-opening metaphor to complexity blinder. *Ecological Economics* 69 (6), 1219-1227.

Richmond, A., Kaufmann R., Myneni, R., 2007, Valuing ecosystem services: A shadow price for net primary production. *Ecological Economics* 64, 454-462.

Yang, Q., Liu, G., Casazza, M., Campbell, E., Giannettia, B., Brown, M., December 2018. Development of a new framework for non-monetary accounting on ecosystem services valuation. *Ecosystem Services* 34A, 37-54.

数据来源

US based data: <https://www.data.gov/ecosystems/>

Satellite data:

<https://www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets>

名词解释:

生物多样性(Biodiversity): 指生态系统中的各种生物;特定区域内的所有生物。

生物圈(Biosphere):地球上被生物体占据的部分,通常包括这些生物与其物理环境之间的相互作用。

生态系统(Ecosystem): 生物圈的一个子集, 主要关注生物与其物理环境之间的相互作用。

生态系统服务(Ecosystem Services): 人类从我们的自然环境和充分运作的生态系统中自由获得的诸多益处和资产。

环境退化(Environmental Degradation: 通过自然过程或人类活动消耗资产来改变或妥协自然环境。

缓解(Mitigate): 减轻严重, 痛苦或有影响力。

估价(Valuation): 指估算或确定某物的当前价值。

ICM 2019 Problem F: Universal, Decentralized, Digital Currency:

Is it possible?

Digital currency can be used like traditional currencies to buy and sell goods, except that it is digital and has no physical representation. Digital currency enables its users to make transactions instantaneously and without any concern for national borders. Cryptocurrency is a subset of digital currency with unique features of privacy, decentralization, security and encryption. Cryptocurrencies have exploded in popularity in various parts of the world; moving from an underground cult interest to a globally accepted phenomenon. Bitcoin and Ethereum, both cryptocurrencies, have grown in value, while investors are projecting rapid growth for other cryptocurrencies such as Dogecoin or Ripple. In addition to digital and cryptocurrencies, there are also new digital methods for financial transactions that enable users to instantaneously exchange money with nothing more than an email address or a thumbprint. Peer-to-peer payment systems

offered by companies like PayPal, Stripe, Venmo, Zelle, Apple Pay, Square Cash, and Google Pay offer virtual movement of money across the globe in seconds without ever having to verify the transaction through a bank or currency exchange. Digital transactions outpace cash and check transactions because they are not delayed by banking policies, national borders, citizenship, debts, or other social-economic factors. These new currency systems decentralize financial transactions, leaving many to consider a world where traditional banking may become obsolete.

Concerns about security of cryptocurrencies worry both citizens and economic analysts. These concerns have constrained its growth in some communities. On the other hand, much of the popularity of cryptocurrency is due to its departure from traditional overly-restrictive security and debt measures that rely on oversight by large banks and governments. These oversight institutions are often expensive, deeply bureaucratic, and sometimes corrupt. Some experts believe that a universal, decentralized, digital currency with internal security like blockchain can make markets more efficient by eliminating barriers to the flow of money. This is particularly important in countries where the majority of citizens do not have bank accounts and are unable to invest in regional or global financial markets. Some governments, however, view the lack of regulation around these currencies and their anonymity as too risky because of how easily they can be used in illicit transactions, such as tax sheltering or purchasing illegal merchandise. Others feel that a secure digital currency offers a more convenient and safer form of financial exchange. For instance, a universally accepted currency would enable truly global financial markets and would protect individual assets against regional inflation fluctuations and artificial manipulation of currency by regional governments. If alternative digital systems become more established, there will be many questions about how digital currency will affect current banking systems and nation-based currencies.

Your policy modeling team has been employed by the International Currency Marketing (ICM) Alliance to help them identify the viability and effects of a global decentralized digital financial market. ICM Alliance has asked you to construct a model that adequately represents this type of financial system, being sure to identify key factors that would limit or facilitate its growth, access, security, and stability at both the individual, national, and global levels. This requires you to consider the different needs of countries and their willingness to work with this new financial marketplace and modify their current banking and monetary models. It may or may not require them to abandon their own currency, so that adds a level of complexity to the market model. You are not to choose an existing digital currency, but discuss the strategies for adoption, and problems in implementation of, a general digital currency. You should also include the mechanisms for oversight of such a global digital currency. The ICM Alliance has asked you to extend your analysis to consider the long-term effects of such a system on the current banking industry; the local, regional, and world economy; and international relations between countries.

ICM requests a report of your modeling and analysis, and a separate one-page policy recommendation for national leaders, who hold mixed opinions about this effort. The policy recommendation should offer rationale for the parameters and dynamics included in your model and reflect the insights you gained from your modeling. Your policies might address, for example, growth, reach, access, security, and stability of the system.

Your team's submission should consist of:

One-page Summary Sheet,

One-page policy recommendation for national leaders,

Your solution of no more than 20 pages, for a maximum of 22 pages with your summary and policy recommendation.

Judges expect a complete list of references with in-text citations, but may not consider appendices in the judging process.

Note: Reference list and any appendices do not count toward the 22-page limit and should appear after your completed solution.

References:

Paul Krugman, “O Canada: A neglected nation gets its Nobel”. Slate, Oct 19, 1999. <https://slate.com/business/1999/10/o-canada.html>

Stephanie Lo and J. Christina Wang, “Bitcoin as Money?” Current Policy Perspectives, Federal Reserve Bank of Boston, 2014. <https://www.bostonfed.org/publications/current-policy-perspectives/2014/bitcoin-as-money.aspx> or <https://www.bostonfed.org/-/media/Documents/Workingpapers/PDF/cpp1404.pdf>

Glossary:

Anonymity – the state of being unnamed or unidentified; the state of being anonymous.

Blockchain – the record keeping technology that can document transactions between two parties in a verifiable and permanent way; a digital database containing information that can be shared and simultaneously used across a large publicly accessible and decentralized network.

Cryptocurrency – a digital or virtual currency that uses cryptography (protecting information through the use of codes) for security.

Digital Currency – [digital money, electronic money, electronic currency] is a type of currency in digital (electronic) versus physical (coins, paper) form.

Illicit – illegal or dishonest.

Fluctuations – variations or oscillations; rises and falls. .

Monetary – relating to money or finances, or to the mechanisms by which money is supplied to and circulates in the economy.

Nation-based currencies – [national currencies] a system of money issued by a central bank and in common use within a particular nation or group of nations; examples are United States dollar (USD), Chinese renminbi (RMB or CNY), European Euro (EUR), British pound sterling (GBP), and Japanese yen (JPY).

Underground cult – hidden or mysterious group of people sharing an excessive devotion toward a particular person, belief, or thing.

ICM 2019 问题-F：通用，分散，数字货币:有可能吗？

数字货币可以像传统货币一样用于买卖商品，除非它是数字化，没有物理表示意义。数字货币使其用户能够即时进行交易而不关心国界。加密货币是数字货币的一个子集，具有隐私，分散，安全和加密的独特功能。加密货币在世界各地的普及程度已近激增。从一个地下邪教的兴趣对一种全球公认的现象。比特币和以太坊都是加密货币已经增长在价值方面，而投资者正在预测其他货币的快速增长加密货币如 Dogecoin or Ripple。除了数字和加密货币之外，还有金融交易的新数字方法，使用户能够即时进行只用电子邮件地址或指纹兑换钱。

对等支付由 PayPal、Stutpe、VunMo、Zelle、苹果支付、平方现金等公司提供的系统 Google Pay 在几秒钟内提供了全球范围内的虚拟货币流动，而无需通过银行或货币兑换验证交易。数字交易超过现金和检查交易，因为它们不会因银行政策、国界、公民身份、债务或其他社会经济因素而延迟。这些新的货币体系分散了金融交易，使得许多人认为传统的银行业可能已经过时。

考虑到加密货币安全性使公民和经济分析师感到担忧。这些关注限制了其在一些社区的增长。这些关注限制了其在一些社区的增长。另一方面，加密货币的大部分流行都是由于它背离了传统的过度限制性安全性以及依赖大型银行和政府监管的债务措施。这些监督机构往往代价昂贵，官僚主义，有时甚至腐败。一些专家相信一种具有内部安全的通用、分散的数字货币，如区块链可以通过消除资金流动的障碍，提高市场效率。这是特别的在大多数公民没有银行账户且无法投资于区域或全球金融市场。然而，一些国家政府认为，缺乏对这些货币的监管以及它们的匿名性太危险，因为它们很容易被用于非法交易，如避税或购买非法商品。其他人认为，安全的数字货币提供了一种更方便、更安全的金融交换形式。例如，一种普遍接受的货币将使真正的全球金融市场得以实现，并将保护个人资产免受区域通货膨胀波动和区域政府人为操纵货币的影响。如果替代数字系统变得更加成熟，那么数字货币将如何影响当前的银行系统和基于国家的货币将会存在许多问题。

建模团队您的政策已被国际货币营销(ICM) 联盟雇佣，以帮助他们确定全球分散数字金融市场的可行性和影响。ICM 联盟要求您建立一个充分代表这种金融体系的模型，确保确定在个人、国家和全球层面限制或促进其增长、准入、安全和稳定的关键因素。这要求您考虑各国的不同需求，以及它们愿意与这个新的金融市场合作，并修改它们当前的银行和货币模型。它可能需要也可能不需要他们放弃自己的货币，这样就增加了市场模式的复杂程度。您不必选择现有的数字货币，而是讨论采用通用数字货币的策略和实施中的问题。以及实施一般数字货币的问题。你还应该包括监督这种全球数字货币的机制。国际货币基金组织联盟已要求您扩展您的分析，以考虑这种制度对当前银行业、地方、区域和世界经济以及国家间国际关系的长期影响。

ICM 要求您提供一份建模和分析报告，并为对这项工作持有不同意见的国家领导人提供一页单独的政策建议。政策建议应该为模型中包含的参数和动力学提供基本原理，并反映您从模型中获得的见解。例如，您的策略可能会解决系统的增长，覆盖范围，访问，安全性和稳定性问题。

您的团队提交的内容应包括:

- 单页摘要表
- 针对国家领导人的单页政策建议
- 您的解决方案不超过 20 页，最多 22 页含摘要和政策建议
- 评委希望提供完整的参考文献列表，其中包含文本引文，但可能不会在评审过程中考虑附录。
- 注意:参考列表和任何附录不计入 22 页的限制应在完成的解决方案后出现。

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Stephanie Lo 和 J. Christina Wang，“比特币作为货币？”当前的政策观点，波士顿联邦储备银行，2014 年

<https://www.bostonfed.org/publications/currentpolicy->

perspectives/2014/bitcoin-as-money.aspx or
https://www.bostonfed.org//media/Documents/Workingpapers/PDF/cp_p1404.pdf

名称解释:

匿名—未命名或未识别的状态;匿名的状态。

区块链—记录保存技术,可以以可验证和永久的方式记录双方之间的交易;数字数据库,包含可在大型公共可访问和分散网络中共享和同时使用的信息。

加密货币—使用加密技术的数字或虚拟货币(保护信息通过使用密码)来保证安全。

数字货币—数字货币、电子货币、电子货币]是数字(电子)货币与物理(硬币、纸张)货币。

非法—非法或不诚实。

波动—变化或振荡;起伏不定(上升和下降)。

货币—与货币或金融相关,或与货币相关的机制供应给经济体并在经济中流通。

基于国家的货币-[国家货币]由中央发行的货币系统银行并在特定国家或国家集团中共同使用;例如是美元(USD),人民币(RMB 或 CNY),欧洲欧元(EUR),英镑(GBP)和日元(JPY)。

地下邪教—隐藏或神秘的一群人分享过度的奉献精神对某个人,信仰或事物

2020 MCM Weekend 1

MCM 2020 Problem A: Moving North

Global ocean temperatures affect the quality of habitats for certain ocean-dwelling species. When temperature changes are too great for their continued thriving, these species move to seek other habitats better suited to their present and future living and reproductive success. One example of this is seen in the lobster population of Maine, USA that is slowly migrating north to Canada where the lower ocean temperatures provide a more suitable habitat. This geographic population shift can significantly disrupt the livelihood of companies who depend on the stability of ocean-dwelling species.

Your team has been hired as consultants by a Scottish North Atlantic fishery management consortium. The consortium wants to gain a better understanding of issues related to the potential migration of Scottish herring and mackerel from their current habitats near Scotland if and when global ocean temperatures increase. These two fish species represent a significant economic contribution to the Scottish fishing industry. Changes in population locations of herring and mackerel could make it economically impractical for smaller Scotland-based fishing companies, who use fishing vessels without on-board refrigeration, to harvest and deliver fresh fish to markets in Scotland fishing ports,

Requirements

Build a mathematical model to identify the most likely locations for these two fish species over the next 50 years, assuming that water temperatures are going to change enough to cause the populations to move.

Based upon how rapidly the ocean water temperature change occurs, use your model to predict best case, worst case, and most likely elapsed time(s) until these populations will be too far away for small fishing companies to harvest if the small fishing companies continue to operate out of their current locations.

In light of your predictive analysis, should these small fishing companies make changes to their operations?

a. If yes, use your model to identify and assess practical and economically attractive strategies for small fishing companies. Your strategies should consider, but not be limited to, realistic options that include:

Relocating some or all of a fishing company's assets from a current location in a Scottish port

to closer to where both fish populations are moving;

Using some proportion of small fishing vessels capable of operating without land-based support for a period of time while still ensuring the freshness and high quality of the catch.

Other options that your team may identify and model.

b. If your team rejects the need for any changes, justify reasons for your rejection based on your modeling results as they relate to the assumptions your team has made.

Use your model to address how your proposal is affected if some proportion of the fishery moves into the territorial waters (sea) of another country.

In addition to your technical report, prepare a one- to two-page article for Hook Line and Sinker magazine to help fishermen understand the seriousness of the problem and how your proposed solution(s) will improve their future business prospects.

Your submission should consist of:

One-page Summary Sheet

Table of Contents

One- to Two-page Article

Your solution of no more than 20 pages, for a maximum of 24 pages with your summary, table of contents, and article.

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.

Glossary

Fishery : The collection of fish of a given species and the area that they inhabit.

Habitat : The type of environment in which an organism or group normally lives or occurs.

Small Fishing Company : A company engaged in commercial fishing with limited or very limited financial resources to invest in new equipment/vessels.

Territorial Waters (sea) : “as defined by the 1982 United Nations Convention on the Law of the Sea, is a belt of coastal waters extending at most 12 nautical miles (22.2 km; 13.8 mi) from the baseline (usually the mean low-water mark) of a coastal state. The territorial sea is regarded as the sovereign territory of the state, although foreign ships (military and civilian) are allowed innocent passage through it, or transit passage for straits; this sovereignty also extends to the airspace over and seabed below.” [Territorial Waters. (n. In Wikipedia. Retrieved January 28, 2020, from

MCM 2020 问题-A: 向北迁徙

全球海洋温度影响某些海洋生物的栖息地质量。当温度变化太大以至于无法继续生长时，这些物种便开始寻找其他更适合其现在和将来的生活和生殖成功的栖息地。其中一个明显的例子就是美国缅因州的龙虾种群，该种群正缓慢地向北迁徙到加拿大，那里较低的海洋温度提供了更合适的栖息地。这种地理上的种群迁移会严重破坏依赖海洋生物物种稳定性的公司的生计。

您的团队已被苏格兰北大西洋渔业管理协会聘为顾问。如果全球海洋温度升高，该财团希望更好地了解与苏格兰鲱鱼和鲑鱼从其目前在苏格兰附近的栖息地迁徙有关的问题。这两种鱼类是苏格兰渔业的重要经济来源。鲱鱼和鲑鱼种群位置的变化可能使以苏格兰为基地的小型捕捞公司在经济上造成不确定风险，后者使用没有船上制冷的渔船来捕捞鲱鱼并将其运送到苏格兰渔港的市场。

要求

.建立一个数学模型，以识别未来 50 年内这两种鱼类最可能的位置，假设水温将发生足够的变化以导致种群移动。

.根据海水温度变化的速度，使用您的模型预测最佳情况、最坏情况和最有可能经过的

时间,直到这些种群距离小渔业公司太远以至于如果小渔业公司继续在其当前位置外作业将一无所获。

.根据您的预测分析, 这些小型捕捞公司是否应该改变其经营方式?

a. 如果是, 请使用您的模型为小型捕捞公司识别和评估实用且经济上有吸引力的策略。您的策略应考虑但不限于现实的选择, 包括:

将部分或全部捕捞公司的资产从苏格兰港口的当前位置迁移到两个鱼类种群都迁徙的附近;

使用一定比例的小型渔船, 这些渔船可以在没有陆上支持的情况下运行一段时间, 同时仍确保渔获物的新鲜度和高质量。

您的团队可以识别和模拟的其他可能的选项。

b. 如果您的团队拒绝进行任何更改, 请根据建模结果来说明拒绝的原因, 因为建模结果与您的团队所做的假设有关。

.使用您的模型来解决:如果有一部分渔业移至另一个国家的领海时您的建议受到的影响。

.除了技术报告外, 还要为 **Hook Line and Sinker** 杂志准备一份长达两页的文章, 以帮助渔民了解问题的严重性以及您提出的解决方案将如何改善他们的未来的业务前景。

您的提交应包括:

一页摘要表

目录

一页至两页的杂志文章

您的解决方案不超过 20 页, 最多包含摘要, 目录和文章的 24 页。

注意: 参考列表和任何附录均不计入页数限制, 应在完成解决方案后显示。您不应使用受版权法限制使用的未经授权的图像和材料。要确保您引用的想法的来源和报告中使用的材料。

专业词汇

渔业: 特定种类的鱼类及其栖息区域的集合。

栖息地: 生物或团体正常生活或发生的环境类型。

小型捕捞公司**: 从事商业捕捞的公司, 其资金来源非常有限或者用于购买新设备/船只的财务资源非常有限

领海(海洋): “根据 1982 年《联合国海洋法公约》的定义, 是一条沿基线延伸最多 12 海里 (22.2 公里; 13.8 英里) 的沿海水带 (通常是指低水位线)。领海被视为国家的主权领土, 尽管允许外国船只 (军用和民用) 无害通过该海, 或过境海峡; 这种主权也延伸到上方的空域和下方的海底。” [领土水域, 于 2020 年 1 月 28 日从维基百科 从 https://en.wikipedia.org/wiki/Territorial_waters 检索。]

总结

1、建立数学模型, 识别未来 50 年两种鱼类最可能的位置, 假设水温将发生足够的变化以导致种群移动

温度数据 (温度与年份的关系), 洋流, 北大西洋渔场, 温度变化模型和鱼类变化、迁徙变化模型如何联系? 预测温度变化反应鱼类种群移动规律

2、根据海水温度变化发生的速度, 使用模型预测最佳情况和最坏情况以及最可能经过的时间, 小型渔业公司继续捕捞至无法获利?

(求出) 变化速度, 最佳情况? 最坏情况? 迁徙变化的时间?

3、根据预测, 判断这些小心捕捞公司是否应该改变其经营方式:

重点: 模型为小型捕捞公司提供识别和评估实用性和经济上有吸引力的策略。

渔业公司港口的迁移如何迁移?

一定比例的小型渔船的出海可以保持获取的新鲜度和高质量?

团队其他特色地方?

小型捕捞公司基本信息 (了解)、公司位置迁移-新的港口位置应该如何安排、

4、提案受到一定比例的渔业 进入另外一个国家临海的影响

5、给杂志的文章：帮助渔民了解问题的严重性和如何改善他们未来的业务前景的解决方案。

MCM 2020 Problem B: The Longest Lasting Sandcastle(s)

Wherever there are recreational sandy ocean beaches in the world, there seem to be children (and adults) creating sandcastles on the seashore. Using tools, toys, and imagination, beach goers create sandcastles that range from simple mounds of sand to complicated replicas of actual castles with walls, towers, moats, and other features that mimic real castles. In all these, one typically forms an initial foundation consisting of a single, nondescript mound of wetted sand, and then proceeds to cut and shape this base into a recognizable 3-dimensional geometric shape upon which to build the more castle-defining features.

Inevitably, the inflow of ocean waves coupled with rising tides erodes sandcastles. It appears, however, that not all sandcastles react the same way to waves and tides, even if built roughly the same size and at roughly the same distance from the water on the same beach. Consequently, one wonders if there exists a best 3-dimensional geometric shape to use for a sandcastle foundation.

Requirements

1. Construct a mathematical model to identify the best 3-dimensional geometric shape to use as a sandcastle foundation that will last the longest period of time on a seashore that experiences waves and tides under the following conditions:

built at roughly the same distance from the water on the same beach, and

built using the same type of sand, roughly the same amount of sand, and the same water-to-sand proportion.

2. Using your model, determine an optimal sand-to-water mixture proportion for the castle foundation, assuming you use no other additives or materials (e.g. plastic or wooden supports, stones, etc.).

3. Adjust your model as needed to determine how the best 3-dimensional sandcastle foundation you identified in requirement 1 is affected by rain, and whether it remains the best 3-dimensional geometric shape to be used as a castle foundation when it is raining.

4. What other strategies, if any, might you use to make your sandcastle last longer?

5. Finally, write an informative, one- to two-page article describing your model and its results for publication in the vacation magazine: Fun in the Sun, whose readers are mainly non-technical.

Your submission should consist of:

One-page Summary Sheet

Table of Contents

One- to Two-page Article

Your solution of no more than 20 pages, for a maximum of 24 pages with your summary, table of contents, and article.

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.

MCM 2020 问题-B: 最持久的沙堡

世界上凡是有休闲沙滩的地方，似乎都有孩子(和大人)在海边堆沙堡。去海滩的人利用各种工具、玩具和想象力，创造出各种各样的沙堡，从简单的沙堆到复杂的带有城墙、塔楼、护城河和其他模仿真正城堡的特征的真实城堡的复制品。在所有这些沙堡中，通常会先形成

一个初始的地基，该地基由一个单一的，无形状的湿沙丘组成，然后将其切割并成形为可识别的 3 维几何形状，从而在其上构建更具城堡意义的特征。

不可避免地，海浪的流入以及涨潮会侵蚀沙堡。然而，即使沙堡是建在同一个海滩上，其大小以及与海水的距离都差不多，似乎并不是所有的沙堡对波浪和潮汐的反应都是一样的。因此，人们想知道是否存在一个最佳的三维几何形状用于沙堡的地基。

要求

1. 建立一个数学模型，以确定在下列条件下，在经历波浪和潮汐的海岸上持续时间最长的沙堡地基的最佳三维几何形状：

在同一海滩上与水的距离大致相同的地方建造，并且

建造使用相同类型的沙子，大致相同数量的沙子，和相同的水到沙子的比例。

2. 假设你没有使用其他添加剂或材料(如塑料或木制的支撑，石头等)，使用你的模型，为城堡的地基确定一个最佳的水沙混合比例。

3. 根据需要调整你的模型，以确定你在需求 1 中确定的最佳三维沙堡地基如何受到雨的影响，以及该地基是否仍然是下雨时用作城堡基础的最佳三维几何形状。

4. 如果可以的话，你还可以使用其他哪些策略来使沙堡持续更长的时间？

5. 最后，写一篇内容翔实、一到两页的文章，描述你的模型及其结果，并发表在度假杂志《阳光下的乐趣》(vacation magazine: Fun in the Sun)上，其读者主要是非技术性人员。

你提交的内容应包括：

- 一页汇总表
- 目录
- 一到两页的文章
- 你的解决方案不超过 20 页，包含摘要和目录在内最多 24 页。

注意：参考列表和任何附录不计入页面限制，应在完成解决方案后显示。因为某些材料使用受到版权法的限制，你不应该使用未经授权的图像和材料。确保你在报告中引用了你的观点和材料。

2020 MCM Weekend 2

MCM 2020 Problem C: A Wealth of Data

In the online marketplace it created, Amazon provides customers with an opportunity to rate and review purchases. Individual ratings - called “star ratings” – allow purchasers to express their level of satisfaction with a product using a scale of 1 (low rated, low satisfaction) to 5 (highly rated, high satisfaction). Additionally, customers can submit text-based messages – called “reviews” – that express further opinions and information about the product. Other customers can submit ratings on these reviews as being helpful or not – called a “helpfulness rating” – towards assisting their own product purchasing decision. Companies use these data to gain insights into the markets in which they participate, the timing of that participation, and the potential success of product design feature choices.

Sunshine Company is planning to introduce and sell three new products in the online marketplace: a microwave oven, a baby pacifier, and a hair dryer. They have hired your team as consultants to identify key patterns, relationships, measures, and parameters in past customer-supplied ratings and reviews associated with other competing products to 1) inform their online sales strategy and 2) identify potentially important design features that would enhance product desirability. Sunshine Company has used data to inform sales strategies in the past, but they have not previously used this particular combination and type of data. Of particular interest to Sunshine Company are time-based patterns in these data, and whether they interact in ways that will help the company craft successful products.

To assist you, Sunshine's data center has provided you with three data files for this project: hair_dryer.tsv, microwave.tsv, and pacifier.tsv. These data represent customer-supplied ratings and reviews for microwave ovens, baby pacifiers, and hair dryers sold in the Amazon marketplace over the time period(s) indicated in the data. A glossary of data label definitions is provided as well. THE DATA FILES PROVIDED CONTAIN THE ONLY DATA YOU SHOULD USE FOR THIS PROBLEM.

Requirements

1. Analyze the three product data sets provided to identify, describe, and support with mathematical evidence, meaningful quantitative and/or qualitative patterns, relationships, measures, and parameters within and between star ratings, reviews, and helpfulness ratings that will help Sunshine Company succeed in their three new online marketplace product offerings.

2. Use your analysis to address the following specific questions and requests from the Sunshine Company Marketing Director:

a. Identify data measures based on ratings and reviews that are most informative for Sunshine Company to track, once their three products are placed on sale in the online marketplace.

b. Identify and discuss time-based measures and patterns within each data set that might suggest that a product's reputation is increasing or decreasing in the online marketplace.

c. Determine combinations of text-based measure(s) and ratings-based measures that best indicate a potentially successful or failing product.

d. Do specific star ratings incite more reviews? For example, are customers more likely to write some type of review after seeing a series of low star ratings? e. Are specific quality descriptors of text-based reviews such as 'enthusiastic', 'disappointed', and others, strongly associated with rating levels?

3. Write a one- to two-page letter to the Marketing Director of Sunshine Company summarizing your team's analysis and results. Include specific justification(s) for the result that your team most confidently recommends to the Marketing Director.

Your submission should consist of:

One-page Summary Sheet

Table of Contents

One- to Two-page Letter

Your solution of no more than 20 pages, for a maximum of 24 pages with your summary sheet, table of contents, and two-page letter.

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.

Glossary

Helpfulness Rating: an indication of how valuable a particular product review is when making a decision whether or not to purchase that product.

Pacifier: a rubber or plastic soothing device, often nipple shaped, given to a baby to suck or bite on.

Review: a written evaluation of a product.

Star Rating: a score given in a system that allows people to rate a product with a number of stars.

Attachments: The Problem Datasets

Problem_C_Data.zip

The three data sets provided contain product user ratings and reviews extracted from the Amazon Customer Reviews Dataset thru Amazon Simple Storage Service (Amazon S3).

hair_dryer.tsv

microwave.tsv

pacifier.tsv

Data Set Definitions: Each row represents data partitioned into the following columns.

● marketplace (string): 2 letter country code of the marketplace where the review was written.

● customer_id (string): Random identifier that can be used to aggregate reviews written by a single author.

● review_id (string): The unique ID of the review.

- product_id (string): The unique Product ID the review pertains to.
- product_parent (string): Random identifier that can be used to aggregate reviews for the same product.
- product_title (string): Title of the product.
- product_category (string): The major consumer category for the product.
- star_rating (int): The 1-5 star rating of the review.
- helpful_votes (int): Number of helpful votes.
- total_votes (int): Number of total votes the review received.
- vine (string): Customers are invited to become Amazon Vine Voices based on the trust that they have earned in the Amazon community for writing accurate and insightful reviews. Amazon provides Amazon Vine members with free copies of products that have been submitted to the program by vendors. Amazon doesn't influence the opinions of Amazon Vine members, nor do they modify or edit reviews.
- verified_purchase (string): A “Y” indicates Amazon verified that the person writing the review purchased the product at Amazon and didn't receive the product at a deep discount.
- review_headline (string): The title of the review.
- review_body (string): The review text.
- review_date (bigint): The date the review was written.

MCM 2020 问题-C: 数据的财富

在其创建的在线市场中, 亚马逊为客户提供了对购买进行评分和评价的机会。个人评级-称为“星级”-使购买者可以使用 1 (低评级, 低满意度) 到 5 (高评级, 高满意度) 的等级来表示他们对产品的满意度。此外, 客户可以提交基于文本的消息 (称为“评论”), 以表达有关该产品的更多意见和信息。其他客户可以根据这些评论提交有帮助或无帮助的等级 (称为“帮助等级”), 以协助他们自己的产品购买决策。公司使用这些数据来深入了解其参与的市场, 参与的时间以及产品设计功能选择的潜在成功。

阳光公司计划在在线市场上推出和销售三种新产品: 微波炉, 婴儿奶嘴和吹风机。他们已聘请您的团队担任顾问, 以识别过去客户提供的与其他竞争产品相关的评分和评论的关键模式, 关系, 度量和参数, 以: 1) 告知其在线销售策略; 2) 识别潜在重要的设计特征, 以提高产品的吸引力。Sunshine Company 过去曾使用数据为销售策略提供信息, 但他们以前从未使用过这种特殊的组合和数据类型。Sunshine Company 特别感兴趣的是这些数据中的基于时间的模式, 以及它们是否以有助于该公司制造成功产品的方式进行交互。

为了帮助您, Sunshine 的数据中心为您提供了该项目的三个数据文件: hair_dryer.tsv, microwave.tsv 和 pacifier.tsv。这些数据代表在数据指示的时间段内在亚马逊市场上出售的微波炉, 婴儿奶嘴和吹风机的客户提供的评分和评论。还提供了数据标签定义的词汇表。提供的文件包含您应用于此问题的唯一数据。

要求

分析提供的三个产品数据集, 以鉴定, 描述和支持数学证据, 有意义的定量和/或定性模式, 关系, 度量和参数, 这些数据将在星级, 评论和帮助等级之内和之间进行, 这将有助于阳光公司取得成功他们的三个新的在线市场产品。

使用您的分析解决 Sunshine Company 市场总监的以下特定问题和要求:

- a. 一旦三种产品在在线市场上出售后, 就可以根据评级和评论确定最能为 Sunshine Company 跟踪的数据度量。
- b. 在每个数据集中识别并讨论基于时间的度量和模式, 这些度量和模式可能表明产品的声誉在在线市场中正在增加或减少。
- c. 确定最能表明潜在成功或失败产品的基于文本的度量和基于评级的度量的组合。

d. 特定星级会引起更多评论吗？例如，在看到一系列低星级评级之后，客户是否更有可能撰写某种类型的评论？

e. 基于文本的评论（例如“热情”，“失望”等）的特定质量描述符是否与评分水平紧密相关？

写一两页给阳光公司市场总监的信，总结您团队的分析和结果。包括针对您的团队最有信心地推荐给市场总监的结果的具体理由。

您提交的内容应包括：

一页摘要表

目录

一页至两页的信函

您的解决方案不超过 20 页，包含摘要页，目录和两页信函最多 24 页。

注意：参考列表和任何附录不计入页数限制，应在完成解决方案后出现。您不应使用未经版权法限制的未经授权的图像和材料。确保您引用了想法的来源和报告中使用的材料。

词汇表

帮助等级：表示在决定是否购买该产品时特定产品评论的价值。

奶嘴：一种橡胶或塑料的舒缓装置，通常为乳头状，提供给婴儿吸吮或咬咬。

审查：对产品的书面评估。

星级：在系统中给出的分数，该分数使人们可以对具有多个星级的产品进行评分。

附件：问题数据集

Problem_C_Data.zip

提供的三个数据集包含通过 Amazon Simple Storage Service (Amazon S3) 从 Amazon 客户评论数据集提取的产品用户评分和评论。

数据集定义：每行代表划分为以下几列的数据。

market (字符串)：撰写评论的市场的 2 个字母的国家代码。

customer_id (字符串)：随机标识符，可用于汇总单个作者撰写的评论。

review_id (字符串)：评论的唯一 ID。

product_id (字符串)：该评论所属的唯一产品 ID。

product_parent (字符串)：随机标识符，可用于汇总同一产品的评论。

product_title (字符串)：产品的标题。

product_category (字符串)：产品的主要消费者类别。

star_rating (int)：评价的 1-5 星级。

help_votes (int)：有用的投票数

total_votes (int)：评论收到的总票数。

vine (字符串)：基于客户在撰写准确而有见地的评论方面所获得的信任，邀请客户成为 Amazon Vine Voices。亚马逊为 Amazon Vine 成员提供了供应商已提交给该程序的产品的免费副本。Amazon 不会影响 Amazon Vine 成员的意见，也不会修改或编辑评论。

verify_purchase (字符串)：“Y”表示亚马逊已验证撰写评论的人在亚马逊上购买了该产品，并且没有以大幅折扣收到该产品。

review_headline (字符串)：评论的标题。

review_body (字符串)：评论文本。

review_date (bigint)：撰写评论的日期

2020 ICM Weekend 1

ICM 2020 Problem 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[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

[1] 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].

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

ICM 2020 问题-D: 合作策略

随着社会的相互联系日益紧密，它们面临的一系列挑战也变得越来越复杂。我们依靠具有不同专业知识和不同视角的跨学科团队来解决许多最具挑战性的问题。在过去的 50 多年里，我们对团队成功的概念理解有了显著的进步，这使得更好的科学、创造性或物理团队能够解决这些复杂的问题。研究人员提出了组建团队的最佳策略、队友之间的最佳互动以及理想的领导风格。跨所有部门和领域的强大团队能够执行复杂的任务，而这些任务是无法通过个人努力或团队成员的一系列附加贡献来完成的。

在竞争性的团队运动中探索团队过程是最有用的设置之一。团队运动必须遵守严格的规则，这些规则可能包括但不限于：运动员的人数、他们的角色、运动员之间允许的接触、他们的位置和动作、得分和违规的后果。团队的成功远远不是单个球员能力的总和。相反，它是基于许多其他因素，涉及到队友在一起的表现。这些因素可能包括团队是否有多样性的技能（一个人可能快，而另一个是精确），团队如何平衡个人与集体之间的性能（明星球员可以很好的利用他们所有队友的技能），以及团队在一段时间内有效协调的能力（随着一名球员

从对手抢断球，另一名球员准备进攻)。

发挥您的建模特长，哈士奇足球队的教练，已经要求您的公司，勇猛的冠军建模(ICM)，帮助他了解球队的动态。特别是，教练要求您去探索球场上球员之间复杂的互动是如何影响他们的成功的。我们的目标不仅是研究直接导致得分的相互作用，而且是探索整个游戏和整个赛季的团队动态，以帮助确定可以提高下赛季团队合作的具体策略。教练要求 ICM 对成功(和失败)的结构和动力特征进行量化和形式化。哈士奇队已经提供了详细的数据 [1] 从上个赛季，包括所有 38 场比赛，他们对他们的 19 个对手(他们打每个对手两次)。总的来说，数据涵盖了 366 名球员 (30 名哈士奇球员，336 名对手球员) 之间的 23429 次传球，以及 59271 场比赛。

为了响应哈士奇教练的要求，您来自于 ICM 的团队应该使用提供的数据来解决以下问题：

为球员之间的传球建立一个网络，每个球员都是一个节点，每个传球都是球员之间的一个链接。使用您的传递网络来识别网络模式，如二元和三元结构和团队队形。还要考虑游戏中的其他结构指标和网络属性。您应该探索多个尺度，如微观(成对的)到宏观(所有球员)的互动，以及时间，如短(分钟到分钟)到长(整场比赛或整个赛季)。

确定反映团队合作成功(除了分数或胜利)的绩效指标，如比赛类型的多样性、球员之间的协调或贡献的分配。您还可以考虑团队过程的其他水平，例如适应性、灵活性、节奏或流畅性。弄清楚战略是普遍有效的还是取决于对手的反战略非常重要。使用您已经确定的绩效指标和团队过程的水平来创建一个模型，来捕获团队工作的结构、配置和动力等方面。

利用从您从团队合作模式中获得的见解来告诉教练，什么样的结构策略对哈士奇是有效的。根据网络分析，教练应该在下个赛季做出哪些改变来提高球队的成功。

您对哈士奇的分析使您能够在一个可控的团队运动环境中考虑群体动力学。理解哪些复杂因素使某些群体比其他群体表现更好，这对社会如何发展和创新至关重要。随着我们的社会越来越多地解决与团队有关的问题，您能概括一下您的发现，谈谈如何设计更有效的团队吗？为了开发团队绩效的通用模型，还需要捕捉团队合作的哪些其他方面呢？您提交的作品应该包括：

一页摘要表

目录

您的解决方案不超过 20 页，包含摘要和目录时最多 22 页。

注意：参考文献和任何附录不计入页面限制，应位于完成解决方案后。您不应该使用未经授权的图像和材料，其使用受到版权法的限制。确保您在报告中引用了您的观点和材料。

附件

2020_Problem_D_DATA.zip

fullevents.csv

matches.csv

passingevents.csv

README.txt

专业名词

Dyadic Configurations: 涉及成对球员的关系。

Triadic Configurations: 3 人一组的的关系。

参考文献

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).

可用资源

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.

2020 ICM Weekend 1

ICM 2020 Problem E: Drowning in Plastic

Since the 1950s, the manufacturing of plastics has grown exponentially because of its variety of uses, such as food packaging, consumer products, medical devices, and construction. While there are significant benefits, the negative implications associated with increased production of plastics are concerning. Plastic products do not readily break down, are difficult to dispose of, and only about 9% of plastics are recycled[1]. Effects can be seen by the approximately 4-12 million tons of plastic waste that enter the oceans each year[1,2]. Plastic waste has severe environmental consequences and it is predicted that if our current trends continue, the oceans will be filled with more plastic than fish by 2050[2]. The effect on marine life has been studied[3], but the effects on human health are not yet completely understood[4]. The rise of single-use and disposable plastic products results in entire industries dedicated to creating plastic waste. It also suggests that the amount of time the product is useful is significantly shorter than the time it takes to properly mitigate the plastic waste. Consequently, to solve the plastic waste problem, we need to slow down the flow of plastic production and improve how we manage plastic waste.

Your team has been hired by the International Council of Plastic Waste Management (ICM) to address this escalating environmental crisis. You must develop a plan to significantly reduce, if not eliminate, single-use and disposable plastic product waste.

Develop a model to estimate the maximum levels of single-use or disposable plastic product waste that can safely be mitigated without further environmental damage. You may need to consider, among many factors, the source of this waste, the extent of the current waste problem, and the availability of resources to process the waste.

Discuss to what extent plastic waste can be reduced to reach an environmentally safe level. This may involve considering factors impacting the levels of plastic waste to include, but not limited to, sources and uses of single-use or disposable plastics, the availability of alternatives to plastics, the impact on the lives of citizens, or policies of cities, regions, countries, and continents to decrease single-use or disposable plastic and the effectiveness of such policies. These can vary between regions, so considering regional-specific constraints may make some policies more effective than others.

Using your model and discussion, set a target for the minimal achievable level of global waste of single-use or disposable plastic products and discuss the impacts for achieving such levels. You may consider ways in which human life is altered, the environmental impacts, or the effects on the multi-trillion-dollar plastic industry.

While this is a global problem, the causes and effects are not equally distributed across nations or regions. Discuss the equity issues that arise from the global crisis and your intended solutions. How do you suggest ICM address these issues?

Write a two-page memo to the ICM describing a realistic global target minimum achievable level of global single-use or disposable plastic product waste, a timeline to

reach this level, and any circumstances that may accelerate or hinder the achievement of your target and timeline.

Your submission should consist of:

One-page Summary Sheet

Table of Contents

Two-page Memo

Your solution of no more than 20 pages, for a maximum of 24 pages with your summary, table of contents, and two-page memo.

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.

Glossary

Disposable Plastic Products: plastic materials or products that are not recyclable and become trash.

Mitigate: To make less severe, to moderate, to alleviate.

Plastic Waste: plastic objects that have not been recycled properly or cannot be recycled; debris made of plastic.

Single-Use Plastic Products: products made of plastic intended for one time use before being discarded.

Cited References

[1] Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, 3(7), e1700782.

[2] Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771.

[3] Li, W. C., Tse, H. F., & Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence and effects. *Science of the Total Environment*, 566, 333-349.

[4] Galloway T.S. (2015) Micro- and Nano-plastics and Human Health. In: Bergmann M., Gutow L., Klages M. (eds) *Marine Anthropogenic Litter*.

ICM 2020 问题-E:淹没在塑料中

自 20 世纪 50 年代以来，由于其用途广泛，如食品包装，消费品，医疗设备和建筑，塑料制造业呈指数型增长。这虽然有很大的好处，但增加塑料生产所带来的消极影响值得关注。塑料产品不易分解，难以处理，大约只有 9% 的塑料被回收利用。每年大约有 400-1200 万吨塑料污染物进入海洋，这带来的影响有目共睹。塑料污染物会对环境造成严重影响，如果按当前的趋势继续下去，预计到 2050 年，海洋当中的塑料将比鱼类更多。科学家对塑料污染物对海洋生物的影响已有研究，但对人类健康的影响尚未完全了解。一次性塑料产品的兴起导致整个行业都开始产生塑料垃圾。这也表明，产品使用时间明显少于适当减少塑料污染物所需要的时间。因此，要解决塑料污染问题，我们需要减缓塑料生产速度，改进处理塑料污染物的方式。

国际塑料废物管理理事会（ICM）聘用你们的团队来解决这一日益严重的环境危机。你们必须制定一个计划，以减少或消除一次性塑料产品污染。

- 开发一个模型来估算可以最大限度地安全减轻一次性塑料产品浪费，但不会造成进一步的环境破坏。在诸多因素中，你可能需要考虑这种污染物的来源，当前污染的严重程度以及处理后污染物的资源可用性。

- 讨论在多大程度上可以减少塑料污染物来达到环境安全水平。可能要考虑的因素包括：影响塑料污染物等级的因素，包括但不限于一次性塑料的来源和用途，塑料替代品的可利用性，对市民生活的影响、城市、地区、国家和大洲制定政策来减少一次性塑料的使用以及这类政策的有效性等。地区之间各有差异，考虑到这一因素，因地制宜制定政策比其他政策更为有效。

- 利用你的模型并讨论，为一次性塑料产品在全球范围内可达到的最低浪费量设定目标值，并讨论达到该值所带来的影响。你可以考虑改变人类生活的方式，对环境或对价值数万亿美元的塑料产业的影响。

• 虽然这是一个全球性问题，但其原因和结果在各个国家或地区之间并不相同。讨论全球危机引起的公平问题以及你打算采取的解决方案。你如何建议 ICM 解决这些问题？

• 写一份两页的备忘录，向 ICM 描述全球一次性塑料产品污染物可达到的现实全球目标最低水平、达到该水平的时间表以及任何可能加速或阻碍实现目标和时间表的情况。

你的意见应包括：

- 一页摘要表
- 目录
- 两页内容的备忘录
- 你的解决方案不得超过 20 页，加上摘要、目录和两页备忘录最多不得超过 24 页。

注意：参考文献和附录不计入页数限制，应在完成解决方案后再出现。不可使用未经授权的图像和材料。确保你引用的观点和报告中使用的材料与参考文献相一致。

词汇表

一次性塑料产品：指不可回收并成为垃圾的塑料材料或产品。

塑料污染物：未经适当回收或不能回收的塑料物体；塑料制成的碎片。

一次性使用塑料制品：用塑料制成的产品，使用一次后丢弃。

2020 ICM Weekend 2

ICM 2020 Problem F: The Place I Called Home...

Researchers have identified several island nations, such as The Maldives, Tuvalu, Kiribati, and The Marshall Islands, as being at risk of completely disappearing due to rising sea levels. What happens, or what should happen, to an island's population when its nation's land disappears? Not only do these environmentally displaced persons (EDPs) need to relocate, but there is also risk of losing a unique culture, language, and way of life. In this problem, we ask you to look more closely at this issue, in terms of both the need to relocate people and the protection of culture. There are many considerations and questions to address, to include: Where will these EDPs go? What countries will take them? Given various nations' disproportionate contributions to the green-house gasses both historically and currently that have accelerated climate change linked to the rising seas, should the worst offenders have a higher obligation to address these issues? And, who gets a say in deciding where these nationless EDPs make a new home – the individuals, an intergovernmental organization like the United Nations (UN), or the individual governments of the states absorbing these persons? A more detailed explanation of these issues is given in the Issue Paper beginning on page 3.

As a result of a recent UN ruling that opened the door to the theoretical recognition of EDPs as refugees, the International Climate Migration Foundation (ICM-F) has hired you to advise the UN by developing a model and using it to analyze this multifaceted issue of when, why, and how the UN should step into a role of addressing the increasing challenge of EDPs. The ICM-F plans to brief the UN on guidance for how the UN should generate a systemized response for EDPs, especially in consideration of the desire to preserve cultural heritage. Your assignment is to develop a model (or set of models) and use your model(s) to provide the analysis to support this briefing. The ICM-F is especially interested in understanding the scope of the issue of EDPs. For example, how many people are currently at risk of becoming EDPs[1]; what is the value of the cultures of at-risk nations; how are those answers likely to change over time? Furthermore, how should the world respond with an international policy that specifically focuses on protecting the rights of persons whose nations have disappeared in the face of climate change while also aiming to preserve culture? Based on your analysis, what recommendations can you offer on this matter, and what are the implications of accepting or rejecting your recommendations?

This problem is extremely complex. We understand that your submission will not be able to fully consider all of the aspects described in the Issue Paper beginning on page 3. However, considering the aspects that you address, synthesize your work into a cohesive answer to the

ICM-F as they advise the UN. At a minimum, your team's paper should include:

An analysis of the scope of the issue in terms of both the number of people at risk and the risk of loss of culture;

Proposed policies to address EDPs in terms of both human rights (being able to resettle and participate fully in life in their new home) and cultural preservation;

A description of the development of a model used to measure the potential impact of proposed policies;

[1] There are multiple estimates for the current and predicted number of climate refugees in the existing literature, but they are vastly different. Therefore, you need to support your conclusions with analysis based on your own model(s), either building off of existing analysis or with a new and independent analysis.

An explanation of how your model was used to design and/or improve your proposed policies;

An explanation, backed by your analysis, of the importance of implementing your proposed policies.

The ICM-F consists of interdisciplinary judges including mathematicians, climate scientists, and experts in refugee migration to review your work. Therefore, your paper should be written for a scientifically literate yet diverse audience.

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.

Glossary

Environmentally displaced persons (EDPs): people who must relocate as their homeland becomes uninhabitable due to climate change events

Cultural heritage: the ways of living of a group or society passed through generations to include customs, practices, art, and values.

ICM Problem F Issue Paper

As noted in the problem statement, several island nations are at risk of completely disappearing due to rising sea levels.[1] The issue is quite complex. It is not simply a matter of identifying how to move a certain number of people around the globe – it is also about recognizing that these people are human beings who have rights and who are the last living representatives of their unique culture. In this Issue Paper, we highlight three of the essential ideas that frame this problem: relocation decisions as they relate to human rights, nation-state responsibility, and individual choice; the tension between assimilation and accommodation as part of resettlement and cultural preservation; and time factors such as the rate of the nation disappearing, the timing of these losses aligning with a global rise in nationalism, and the difficulty in making sound predictions about the size of this issue.

Relocation Decisions: Human Rights, Nation-State Responsibility, and Individual Choice

Considering the relocation issue, you might think that such EDPs would have similar rights as other UN-recognized refugees, but the United Nations High Commission on Refugees (UNHCR) and the widely adopted 1967 protocol has historically only afforded rights to those who are displaced due to politically related security issues, such as ethnic or religious persecution. However, in a very recent ruling, the UN has acknowledged this issue and recognized that some EDPs might qualify as refugees.[2] Although a ruling has now been made, there is not yet a vision on how the international community should respond as these situations increase in magnitude and frequency.[3]

Rights awarded to these refugees include right to work, freedom of movement, and protection by host governments. Additionally, the UNHCR, in collaboration with other aid organizations, work to provide aid and assistance to refugees until they are resettled in another country, become naturalized by their host state, or repatriate to their country of origin. Now, with this new ruling, the former inhabitants of the disappeared nation may be eligible for some of those rights or aid,

but there is no hope of repatriation as the land itself is gone.

Even if EDPs are eligible for rights somewhere else, it is not clear where this new home would be or who would be responsible for making that decision. There are individual and international considerations related to whether the selection of a new long-term residence is made by individuals or if the choices are made or swayed by immigration policies developed by nations in isolation or as part of a cooperative effort coordinated by the United Nations. Possible migration policies could consider the financial ability of the new nation to absorb these new individuals, but there is also discussion of setting up burden-sharing based on nations' relative contributions (pollution) to the environmental conditions that is leading to the loss of these nations. In other words, the international community may press nations with high pollution records to contribute more to the resettlement of EDPs in some equitable manner.

Resettlement and Cultural Preservation: Assimilation versus Accommodation

In terms of the cultural preservation issues, the nations that are most at risk are arguably some of the most culturally distinct in the world with languages, music, art, dances, social norms, and ways of life that can be different from island to island even within the same island chain. As a result, the loss of one of these nations could represent a significant cultural loss. While the displaced inhabitants may be able to preserve some aspects of their culture, some are geographically specific. For example, traditional ocean fishing techniques used in The Marshall

Islands are unlikely to continue to be practiced by families who settle in the Alps. As another example, perhaps the language could be preserved, but this would require host nations to be more accommodating and less strict on the assimilation requirements of these special new residents who may be trying to preserve their culture in a new land. For example, France currently requires refugees who resettle there to learn French, but if there were international pressure, perhaps France would waive this requirement for groups of EDPs who are trying to preserve a lost culture.

This leads to a tension between accommodation and assimilation as other nations volunteer to absorb the populations of the former nations. It is important to note that it is the lack of a UN protocol for dealing with EDPs that forces other nations to volunteer to settle and naturalize those affected. In fact, the loss of a nation falls into the no-man's land between several UN charges – the care of refugees (UNHCR), the protection of world culture (United Nations Educational, Scientific, and Cultural Organization (UNESCO)), and emergency aid response (United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA)). And while the residents of a handful of small island nations might be absorbed relatively easily by volunteer nations, the fact is that climate change has been ushering a literal wave of more frequent and more intense environmental disasters. Imagine a major tsunami taking out a nuclear power plant and causing enough other significant damage that a more heavily inhabited nation may become uninhabitable; or a place being hit by so many repeated severe storms that rebuilding was deemed unwise; or a place where climate change is making it impossible for a nation that was formerly flush with crops to provide for its people. At what point should the UN step in, and in what role?

Time Factors: Raging Waves, Rising Seas, and Rising Nationalism

If a nation is wiped out as a result of a rapid catastrophic event, such as a tsunami or hurricane, then there is no time to prepare, even if the country knew they were at risk of such an event. When a nation is sinking as a result of slowly rising sea levels, then there are issues about how a migration could be coordinated and planned, or even how the loss could be mitigated through land-preserving measures taken by the at-risk nation with or without international support. It is not clear how the timescale of the loss would impact, or should impact, the ultimate decisions that need to be made concerning the resettlement of a population, the protection of their human rights, and the preservation of their culture.

Additionally, as the urgency to address this issue is literally rising with the sea level, the world is also experiencing a rise of nationalism, so the global response today may be very different than it would have been at other periods in history where globalism may have been more in favor than nationalism. If policies, or a lack of policies, end up pushing EDPs towards a subset of welcoming nations, then those countries may get overwhelmed and become less welcoming in response. Therefore, the changing global political climate may also be an important factor to consider.

Lastly, all of these challenges make the size of this problem extremely difficult to predict. Credible studies have predicted anywhere from 140 million to one billion EDPs by 2050.[4,5]

Summary:

In summary, as a nation disappears, it is not clear if an international cooperative and coordinated effort should be adopted to address the loss of homes, the need to resettle, and the preservation of culture. This issue is complex, and no model or report would be able to adequately address every

aspect in detail, but excellent reports need to be aware of these different aspects and how they are interrelated. There is the aspect of human rights, which are now recognized in theory, but have never been applied in practice. There is the balance of individual choice versus policy-driven migration. Another aspect is defining equitable burden sharing which could be driven by the capacity for nations to absorb new residents and/or obligations due to contributions to climate change; specifically, whether the nations with the largest contributions to climate change have any ethical obligations to take on a higher burden in assisting climate refugees. Yet another aspect is a balance between assimilation and accommodation, as new residents preserve their culture and/or blend into their new home. Some nations may disappear slowly, such as sinking under rising sea levels or loss of the ability to produce food, while other nations may be wiped out in a catastrophic disaster; and the immediate needs and ability to plan for the long-term needs in these situations are different. Furthermore, the situation is evolving over time as climate change advances and as we see a global rise in nationalism. Lastly, all of this complexity has made it difficult to even measure the problem or predict how quickly it will escalate.

Cited References Note that these are provided as citations to support claims in the Issue Paper. We have already pulled the important ideas from these resources for you, so although your team may use these sources, access to these is not required. Instead your team is encouraged to look for other sources to support your claims.

[1] Letman, J. (2018, November 19). Rising seas give island nation a stark choice: relocate or elevate. National Geographic. Retrieved from <https://www.nationalgeographic.com/environment/2018/11/rising-seas-force-marshall-islands-relocate-elevate-artificial-islands/>.

[2] Young, M. (2019, December 9). Climate Refugees Refused UN Protection & Denied Rights Under International Law. Retrieved from <http://www.ipsnews.net/2019/12/climate-refugees-refused-un-protection-denied-rights-international-law/>.

[3] Su, Y. (2020, January 29). UN ruling on climate refugees could be gamechanger for climate action. Retrieved from <https://www.climatechangenews.com/2020/01/29/un-ruling-climate-refugees-gamechanger-climate-action/>.

[4] The World Bank Report. (2018, March 19). Climate Change Could Force Over 140-Million to Migration Within Countries by 2050. Retrieved from <https://www.worldbank.org/en/news/press-release/2018/03/19/climate-change-could-force-over-140-million-to-migrate-within-countries-by-2050-world-bank-report>.

[5] Kamal, B. (2017, August 21). Climate Migrants Might Reach One Billion by 2050. Retrieved from <http://www.ipsnews.net/2017/08/climate-migrants-might-reach-one-billion-by-2050/>.

ICM 2020 问题-F: 那个我称之为家的地方...

研究人员已经确认了几个岛国，如马尔代夫、图瓦卢、基里巴斯和马绍尔群岛，由于海平面上升而面临着完全消失的危险。当一个国家的土地消失时，岛上的人口会发生什么，或者应该发生什么？这些环境流离失所者(EDPs)不仅需要重新安置，而且还有失去独特文化、语言 and 生活方式的危险。在这个问题上，要求你更仔细地考虑重新安置人口和保护文化两方面。

许多问题需要考虑和解决，包括:这些环境流离失所者将何去何从？哪些国家将接受他们？从历史上和现在两个角度来看，各国对温室气体的贡献都不成比例，这些温室气体加速了与海平面上升相关的气候变化，那么，最严重的违法者是否有更大的义务来解决这些问题呢？而且，在决定这些无国籍的流离失所的让你在何处安家的问题上，谁有发言权？是个人，是像联合国这样的政府间组织，还是吸收这些人的各国政府？关于这些问题的更详细的解释在之后的发行文件第3页给出。

由于联合国最近的一项裁决打开了将因环境而流离失所的人当做难民的理论认可的大门，因此国际气候迁移基金会（ICM-F）聘请你为联合国提供咨询意见，方法是建立模型并用其来分析这一多方面的问题，即联合国何时，为什么以及如何扮演角色来应对日益严重的EDP挑战。国际气候迁移基金会计划向联合国简要介绍有关联合国应如何为EDP产生系统

反应的指南，特别要考虑到保护文化遗产的意愿。你的任务是构建一个（或多个）模型并使用该模型来提供分析以支持此简介。国际气候迁移基金会对了解 EDP 问题的范围特别感兴趣。例如，目前有多少人成为 EDP 的风险；高危国家文化的价值是什么？这些答案可能会随着时间变化吗？此外，以专门侧重于保护那些因气候变化导致国家消失的国民的权利，同时还以保护文化为目标，世界应如何制定一项国际政策？根据你的分析，你可以针对此问题提供哪些建议，接受或拒绝你的建议有什么影响？

这个问题极其复杂。我们理解，你提交的解决方案将不能完全考虑第 3 页开始的问题文件中描述的所有方面。然而，考虑到你所涉及的各个方面，综合你的工作，就像他们向联合国建议的那样，形成对国际货币基金组织的一个有凝聚力的回答，至少，你的团队的论文应该包括：

- 1 从面临风险的人数和失去文化的风险两方面分析问题的范围；
- 1 基于人权(能够重新定居并充分参与新家园的生活)和文化保护解决环境流离失所者的拟议政策；
- 1 一份衡量拟议政策潜在影响的模型的发展情况的说明；
- 1 一份如何使用你的模型来设计和/或改进你提出的策略的说明；
- 1 根据你的分析，解释实施您所提议的政策的重要性。

国际气候迁移基金会由包括数学家、气候科学家和难民移民专家在内的跨学科评审组成，他们将对您的工作进行评审。因此，你的论文阅读对象应该是来自不同行业但有科学素养的读者。

你提交的内容应包括：

- 1 一页汇总表
- 1 目录
- 1 您的解决方案不超过 20 页，包含摘要和目录在内最多 22 页。

注意：参考列表和任何附录不计入页面限制，应在完成解决方案后显示。因为某些材料使用受到版权法的限制，你不应该使用未经授权的图像和材料。确保你在报告中引用了你的观点和材料。

术语

环境流离失所者：由于气候变化事件，由于家园变得无法居住而必须迁移的人

文化遗产：一个群体或社会经过几代人的生活方式，包括习俗、习俗、艺术和价值观。

F 题发行文件

正如在问题声明中所指出的，由于海平面上升，一些岛屿国家面临着完全消失的危险。[1]这个问题相当复杂。这不仅仅是一个确定如何在全球范围内转移一定数量的人的问题，这也是一个认识到这些人是有权利的人，是他们独特的文化最后活着的代表。在这篇论文中，我们强调了构建这一问题的三个基本概念：涉及人权、民族国家责任和个人选择的搬迁决定；作为移民安置和文化保护的一部分，同化和迁居之间的紧张关系；时间因素，如国家消失的速度，这些损失的时间与全球民族主义的上升相一致，以及很难对这个问题的规模做出合理的预测。

搬迁决定：人权、国家责任和个人选择

考虑到搬迁问题，您可能会认为这种环境流离失所者与其他联合国认可的难民具有相似的权利，但联合国难民事务高级专员公署（UNHCR）和被广泛采用的 1967 年议定书历来仅向因种族或宗教迫害等政治相关安全问题而流离失所的人提供权利。

但是，在最近的裁决中，联合国承认了这个问题，并认识到某些环境流离失所者可能有资格成为难民。[2] 尽管现在已经作出了裁决，但对于随着这些局势的规模和频率的增加，国际社会应如何应对尚无一个构想。[3]

给予这些难民的权利包括工作的权利、行动的自由和东道国政府的保护。此外，难民专员办事处与其他援助组织合作，努力向难民提供援助，直到他们被重新安置在另一个国家，被东道国归化，或被遣返原籍国。现在，有了这项新的裁决，失踪国家的前居民可能有资格获得其中的一些权利或援助，但由于土地本身已经消失，并没有希望遣返。

即使 EDP 有资格在其他地方获得权利，也不清楚这个新家在哪里，也不清楚谁将负责做出这个决定。个人和国际上都有一些考虑，包括是选择新的长期居住地是由个人作出的，还是由孤立的国家制定的移民政策作出或影响的选择，或作为联合国协调的合作努力的一部

分。可能的移民政策可以考虑新国家吸收这些新移民的财政能力,但也有建立基于国家对环境条件的相对贡献(污染)导致这些国家损失的负担分担的讨论。换句话说,国际社会可以向有高污染记录的国家施加压力,要求其以某种公平的方式为 EDP 的重新安置作出更多贡献。

重新安置和文化保护:同化与迁居

就文化保护问题而言,受威胁最大的国家可以说是世界上最具文化特色的国家之一,它们的语言、音乐、艺术、舞蹈、社会规范和生活方式可能因岛屿而异,即使是在同一岛链内也是如此。因此,失去其中一个国家可能代表重大的文化损失。虽然流离失所的居民可能能够保存他们文化的某些方面,但有些是地理上特定的。例如,在马绍尔群岛使用的传统海洋捕鱼技术不太可能继续被居住在阿尔卑斯山的家庭采用。再举一个例子,也许语言可以被保留下来,但这就要求居住国对这些特殊的新居民的同化要求更宽容,不那么严格,而这些新居民可能正试图在一个新的土地上保存他们的文化。例如,法国目前要求难民重新定居在那里学习法语,但如果有国际压力,也许法国会放弃这一要求的 EDP 团体,他们试图保存一个失去的文化。

这导致了适应和同化之间的紧张关系,因为其他国家自愿吸收前国家的人口。需要指出的是,正是由于缺乏联合国处理 EDP 的议定书,其他国家才被迫自愿安置并使受影响的人入籍。事实上,一个国家的丧失落在几个联合国职责之间的无人区——照顾难民(UNHCR)、保护世界文化(联合国教育、科学及文化组织(UNESCO))和紧急援助反应(联合国人道主义事务协调办公室(UNOCHA))。虽然少数小岛国的居民可能相对容易被志愿国吸收,但事实是,气候变化已经引发了一波更频繁、更严重的环境灾难。想象一下,一场巨大的海啸摧毁了一座核电站,并造成了足够多的其他重大破坏,让一个人口更密集的国家变得无法居住;或者一个地方被多次重复的严重风暴袭击,以至于重建被认为是不明智的;或者是一个气候变化使一个曾经盛产粮食的国家无法养活人民的地方。联合国应该在什么时候介入,扮演什么角色?

时间因素:汹涌的浪潮、上升的海洋和上升的民族主义

如果一个国家因为迅速的灾难性事件,如海啸或飓风,而被摧毁,那么即使这个国家知道他们面临着这样的风险,也没有时间去准备。

当一个国家因海平面缓慢上升而下沉时,就会出现这样的问题:如何协调和规划移民,甚至如何通过陆地减少损失有或没有国际支持的处于危险中的国家采取的措施。目前尚不清楚损失的时间尺度将如何影响或应如何影响需要就重新安置一个人口、保护他们的未来作出的最终决定保护他们的文化。

此外,由于解决这一问题的紧迫性正随着海平面的上升而上升,世界也正在经历民族主义的兴起,因此今天的全球反应可能是非常不同的。如果政策,或者缺乏政策,最终将 EDP 推向一小部分友好国家,那么这些国家可能会不知所措,变得不那么友好。因此,全球政治气候的变化也可能是一个需要考虑的重要因素。

最后,所有这些挑战使得这个问题的规模极其难以预测。

可靠的研究预测,到 2050 年,EDP 将在 1.4 亿到 10 亿之间。[4] [5]

总结

总而言之,当一个国家消失时,我们不清楚是否应该采取国际合作和协调的努力来解决失去家园、需要重新定居和保护文化的问题。这个问题很复杂,没有模型或报告能够充分详细地处理每个方面,但是优秀的报告需要了解这些不同的方面以及它们之间的相互关系。有一个方面是人权,它现在在理论上得到承认,但从来没有在实践中得到应用。个人选择与政策驱动的迁移之间存在平衡。另一个方面是定义公平的责任分担,这可以由各国吸收新居民的能力和/或因对气候变化的贡献而承担的义务来推动;具体来说,对气候变化贡献最大的国家是否有道德义务在援助气候难民方面承担更大的负担。另一个方面是同化和适应之间的平衡,因为新的居民保存他们的文化和/或融入他们的新家。有些国家可能会慢慢消失,如在海平面上升的情况下下沉或失去生产粮食的能力,而其他国家可能会在一场灾难性的灾难中消失;在这些情况下,即时需求和为长期需求做计划的能力是不同的。此外,随着气候变化的推进,以及我们看到全球民族主义的抬头,形势也在不断演变。最后,所有这些复杂性使得我们甚至难以衡量问题或预测问题将会以多快的速度升级。

参考文献

请注意,这些内容作为引用提供,以支持问题文件中的观点。我们已经为你从这些资源

中提取了重要的想法，因此，尽管你的团队可以使用这些资源，但不需要访问这些资源。相反，鼓励您的团队寻找其他来源来支持你的观点。

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