车位分布的优化设计与评价

摘要：

随着国家经济的发展，越来越多的市民都拥有了私家车。车辆的急剧增长，带动了人们对车位的迫切需求。但是在享受汽车带来的迅捷与便利的同时，我们自身的活动开始为它所困扰。由于规划设计的滞后，造成城镇居住小区相关停车的规划与设计处于一种混沌状态，给私人汽车的拥有者和小区居民带来困扰，并且越来越成为当前的一个社会问题。

针对问题 1，通过对居民工作时间，停车场的服务半径和居民步行距离等多方面的分析，我们得出评判车位分布是否合理的关键指标有三个，分别是居民从电梯（楼梯）口到停车位的步行路程、工作日上下班高峰时期输送的人流量和楼层高度。基于三个评判指标，我们建立了三个模型。模型一按居民从楼中出来的先后顺序分配停车位，利用 0-1 规划，以所有居民从电梯（楼梯）口到停车位的最短步行总路程为目标函数，得到停车场最优化的车位分布方案。为了让居民出行不造成拥堵，我们在模型二中采用将车位分块的方法，合理的将同一批出车的居民分散开，增加了彼此之间的距离，使得出车尽可能的不会相互干扰 。模型三中考虑高峰时期，建立居民经电梯出行情况的模型，从而得到高峰时期电梯每次运载的居民所住楼层情况，并获得他们之间的时间间隔。

针对问题 2，我们以问题一中的模型一为基础，利用 0-1 规划求出附件 1 中停车场的最优车位分布方案，并与原车位分布方案做对比，通过比较在这两种方案下所有居民从电梯（楼梯）口到停车位的最短步行总路程以及单人最长步行路程来评价附件 1 的车位分布方案的合理性。

针对问题 3，我们运行了问题二的 Lingo 程序，对居民按从楼中出来的先后顺序进行编号，便得到了该编号与最优化车位分布方案的车位号之间的对应关系。再进行合理的假设，分析出居民从楼中出来的先后顺序与居民的房间号之间的对应关系。从而得到居民的房间号与车位号之间的对应关系，即最优化的车位分布方案。

关键词：最短步行总路程；0-1 规划；车位分布

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正 文

1 问题重述与分析

随着现代社会经济的快速发展，房地产成为国家经济发展中重要的经济增长点之一。而小区内汽车停车位的分布对于小区居民的上下班出行影响很大，建立数学模型，分析小区汽车停车位分布是否合理，评判附件 1 中车位分布的合理性，并给出一个合理的车位分布。

居住区停车行为规律[1]

- **时间特性**

居住区居民的停车行为具有一定的时间分布特性，具体分析如下：

① 停车数量早、中、晚高峰分明

对于大部分居民来讲，工作日出车、开车、停车是最常见的活动，其中停车、出车工作时间大部分总是相似的。这也就造成了工作日每天在居住区的停车、出车行为会产生峰值与波谷的效应，居住区停车数量呈现早、中、晚高峰分明的特点。

② 工作日与节假日停车区别明显

居民工作日的出行目的大多为上下班出行，具有一定的时间分布特性。但是节假日居民的出行种类众多，如探亲访友、娱乐、购物、旅游等，且随意性大，出行时间宽裕，不像上下班、公务等那样严格。部分居民也许不选择小汽车出行，而选择环保、便捷的公共交通出行方式。故节假日居住区停车无明显规律可言，成随机分布。

③ 中午与晚间停车方式各异

出车时对于交通道路、门禁的要求是迅速通过性，而中午与晚间的停车方式因出车与否也有所不同。中午因为要考虑下午出车，停车时间短，大部分人把对停车的安全性要求调低，停放在路边或地面停车场，这一时段主要是对取车方便的要求。当晚上车主驾车回家进行停车时，他们又会把停车的安全性要求提高，忽略取车方便性，选择地下或立体停车场库。

- **空间特性**

居民停车行为除了具有时间上的分布特性外，也具有一定的空间特性。

① 停车步行距离和步行道设计[2]

居住区停车场的规划设计，应充分考虑居民的停车步行距离，避免步行距离过长而影响停车设施的使用。根据调研资料分析，大多数小区居民在小区内愿意接受的停车步行距离在 100 米以内，这与《城市居住区规划设计规范》对停车服务半径的要求不大于 150 米相近。小区居民停车最理想的地方是住宅门口，故停车需求最原始的发出点应该是住宅楼出入口附近。所以，居住区的停车需求分布从宏观上看与居住区规划结构、组团方式、动态交通组织设计以及总体布局息息相关，从微观上看与停车步行距离、停车场的可达性、停车对周边交通及居民生活的干扰程度关系密切。居住区的配建车位除了要满足基本车位所住居民停车需求之外，还应考虑来访者车辆的停放，以免来访车辆占道停车，影响居住区环境。

表 1.1: 考虑小汽车密度和服务半径的停车场规模推荐值 [3]

小汽车密度（区内小汽车拥有率× 区内住宅平均层数）	建议停车规模（服务半径为 100 米）	
	停车场位于服务区中央（车位）	停车场位于服务区一侧（车位）
1.2	90~100	——
1.8	130~140	70~80
2.4	170~180	90~100
3.0	210~220	110~120

2 基本假设

1）居民区的车辆均为小型车，所有停车位的尺寸均为统一规格；

2）车位的分布基本是规则的；

3）上班高峰时期，每户均只有一位居民上班，且需驾车上班；

4）居民与车辆为一一对应关系，即所有车都要出动；

5）小区的所有私家车全都停放在该小区，该小区不接受其它小区私家车停放；

6）车位供应量为小区停车位最大供应量，没有其它外来因素占用或干扰，从而影响停车位的使用；

7）所有居民均在上下班高峰期使用车辆。

3 符号说明

D	所有车位到电梯（楼梯）口的总距离
D_i	第 i 个单元车位到电梯口的距离
d	一个车位到电梯（楼梯）口的距离
X_I	第 i 个车位的横坐标
Y_i	第 *i* 个车位的纵坐标
X_0	电梯（楼梯）口的横坐标
Y_0	电梯（楼梯）口的纵坐标
L	车位长度
W	车位宽度

4 模型的建立与求解

4.1 问题 1

在问题分析模块中，我们通过分析居住区停车行为的时间特性可以看出，居民停车行为在一天内中基本呈对称分布，车流量高峰主要集中在早晨上班时间和

晚上下班时间。通过分析居住区停车行为的空间特性，我们可以看出居民喜欢选择步行距离较近的车位停车。

评判小区汽车停车位分布是否合理的几个关键指标

一个好的车位分布不仅能减少居民的步行距离，减轻劳累，还可以在上下班高峰期减小堵车的频率，避免阻塞给居民带来的不便，在短时间内尽可能输送更多的人流量。所以我们认为评判小区汽车停车位分布是否合理的几个关键指标为：

① 居民从电梯（楼梯）口到停车位的步行路程；

② 上下班高峰期输送的人流量；

③ 楼层高度。

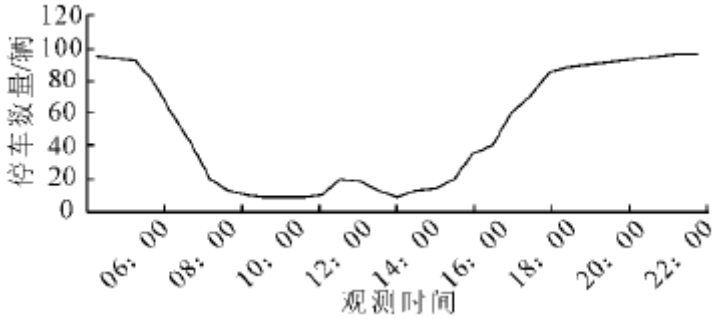

图 4.1.1: 工作日居住区停车数量随时间变化情况[2]

说明： 由于一天中居住区居民停车行为基本呈对称分布，所以在下面研究问题时，我们只考虑早晨上班时间的车流量高峰。

4.1.1 模型一 居民从电梯（楼梯）口到停车位的步行路程模型

车位分布的评价标准最直观的因素就是停车位到电梯（楼梯）口的距离。车位距离电梯（楼梯）口越近，人们步行距离就越短，取车时间就会减少。

如图 4.1.2 所示，我们用 MATLAB 随机产生一群点，这群离散的点的位置就如同车位的位置，它们与不同电梯的距离有所差异。假设停车场里有两个电梯，那么这群点应该如何分布才会使它们到电梯的总距离更短一些?

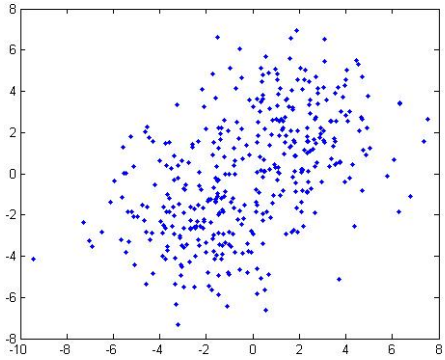

图 4.1.2

模型的建立

我们建立平面直角坐标系，其中电梯的位置坐标为（X_0, Y_0）。我们对所有

的车位按顺序进行编号，（X_i, Y_i）代表第 i 个车位的坐标位置。那么，一位居民从电梯（楼梯）口到第 i 个停车位的距离为

$$d = \sqrt{(\mathrm{X}_i - \mathrm{X}_0)^2 + (\mathrm{Y}_i - \mathrm{Y}_0)^2} \qquad 【1】$$

一个单元 n 位用户的车位到楼梯口的距离为

$$D = \sum_{i=1}^{n} \sqrt{(\mathrm{X}_i - \mathrm{X}_0)^2 + (\mathrm{Y}_i - \mathrm{Y}_0)^2} \qquad 【2】$$

同一停车场内m个单元的所有居民步行距离的总和为

$$\mathrm{D} = \sum_{j=1}^{m} D_j = \sum_{j=1}^{m} \sum_{i=1}^{n} \sqrt{(\mathrm{X}_i - \mathrm{X}_0)^2 + (\mathrm{Y}_i - \mathrm{Y}_0)^2} \qquad 【3】$$

如果停车场内只有一个电梯，这个总距离是不变的。考虑到一幢楼里可能有多个单元共用一个停车场，一个停车场内就有多个电梯，每个电梯对应不同的单元，方程【2】和【3】所对应的距离就会发生变化。我们不可能使每一位居民到达停车位的距离都达到最短，但是对于所有单元的居民用户，我们应该使所有用户到停车位的总距离尽量的短。比如同一幢楼里一般会有 2~3 个单元，这些单元的车位是在一起的。

为了保证所有用户到停车位的总距离最短，需要将停车位划分一下。在此，我们采用了 K-means 的思想进行初步分析，得出当这群点大致按图 4.1.3 分布时效果会更好！并在此基础上，我们用了 0-1 规划，以所有居民从电梯（楼梯）口到停车位的最短步行总路程为目标函数，借助 Lingo 软件，得到停车场最优化的车位分布方案。

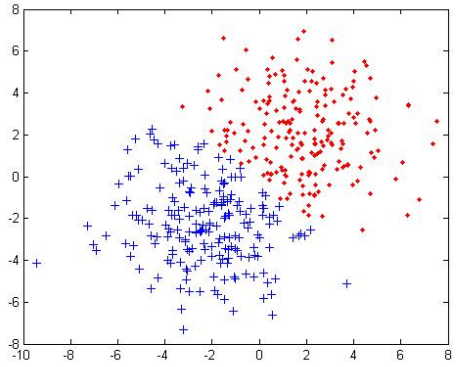

图 4.1.3

模型评价与改进

在模型一中，根据停车场的各个车位到每个单元电梯（楼梯）的距离不同，我们将车位进行了合理的重新排布，使得车位的位置与每个单元有了很好的对应

关系。这样，在接下来的问题中我们只需要考虑一个单元的车位分布即可。由于我们仅仅是考虑了车位到电梯（楼梯）之间的距离对居民步行时间造成的影响，忽略了楼层高度和上下班高峰期的人流量对车位分布的要求。事实上，人们对上下班高峰期的人流量要求更高一些。因为良好的车位分布能缓解小区内的交通拥挤状况，增加单位时间内的车流量，给上班族缓解交通阻塞的压力，同时可以减少交通事故的发生。下面我们将通过建立一个新的模型，来完善模型一的不足。

4.1.2 模型二　车位分布分块模型

在模型一中，我们已经将不同的车位划分到不同的单元，在模型二中我们只考虑一个单元的车位。

图 4.2.1 是某小区停车场的局部分布图。如果有多个人同时去上班，假设他们的停车位聚集在一起，那么多个人不可能同时开车，相干扰的车辆只能有一辆车先行，其他车辆只能等待，这样子必然耽误出行人的时间，影响出行效率，还会造成交通拥堵。

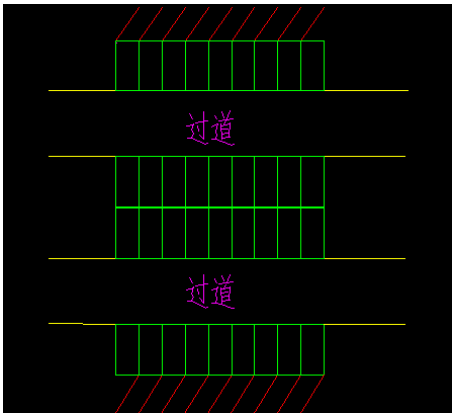

图 4.2.1

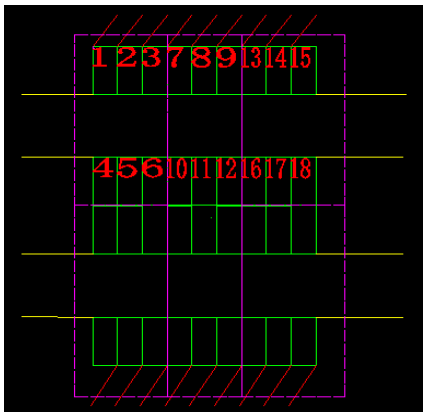

图 4.2.2

为了解决这个问题，我们采用将停车位分块的方法。如图 4.2.2 所示。我们根据车位的规格（2.4m*5.3m），将每六个车位划分到一起，称它们为一个集合，不同的六个车位为不同的集合。图 4.2.2 中 1 号到 18 号共分为三个集合，分别为

$$\begin{cases} [1，\ 2，\ 3，\ 4，\ 5，\ 6] \\ [7，\ 8，\ 9，\ 10，\ 11，\ 12] \\ [13，\ 14，\ 15，\ 16，\ 17，\ 18] \end{cases}$$

如果同时有三位居民开车出库，我们可以将这三位居民分别分到每个集合中，如 1 号，11 号，18 号，由于这三个车位相隔比较远，可以同时出车，并且出车安全系数比较高，还不会造成阻塞现象。也就是说同时来停车场取车的人，如果他们分别到不同地方去取车，由于他们车位距离相对较远，这样子就不会彼此干扰，或者干扰的程度较小。在这种情况下，人们的出行效率就会提高很多。基于这种思想，我们建立新的模型。

模型的建立

由于每位居民每天车出库的时间是相同的，居民每天的出行顺序基本不变。我们根据每位居民每天早晨出门的先后顺序进行标号。第一位出行的居民标记为 1 号，第二位出行的居民标记为 2 号，依次类推。将所有标号的居民按照顺序每 15 个人归为一组，第一组的包括 1 到 15 号。对于同一批次的 15 个人，他们所去的车位坐标为（X_i, Y_i），两个车位的间隔距离满足

$$\begin{cases} \sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2} \geq 2W \quad i \in 1,2,\dots,15 \quad j \in 1,2,\dots,15 \\ i \neq j \end{cases} \qquad 【4】$$

其中，2.4 表示车位的宽度，2 代表两个车位。

利用 MATLAB 对停车区高峰时段进行仿真，程序见附录。

假设在一条道路上，有 60 个停车位，居民同时从居民楼出发开车上班的情况如图 4.2.3

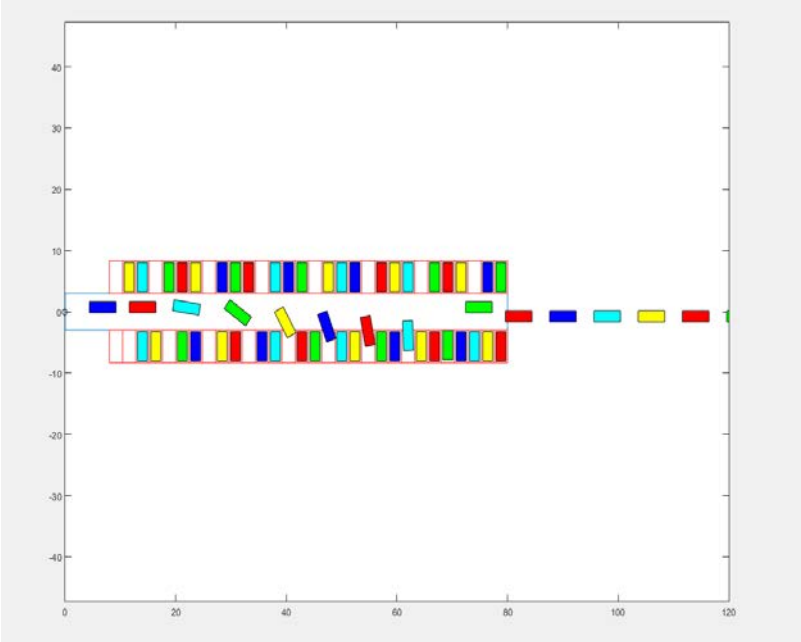

图 4.2.3

仿真结果：最早离开小区的车辆花费时间：68.2 秒。

最后离开小区的车辆花费时间：247.4 秒。

当有 100 个停车位时，居民同时从居民楼出发开车上班的情况如图 4.2.4

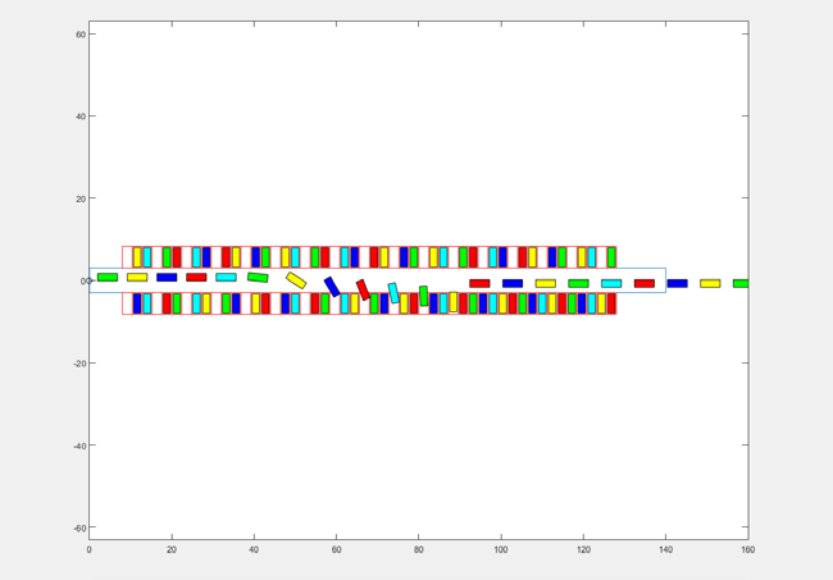

图 4.2.4

仿真结果：最早离开小区的车辆花费时间 104.2 秒.

最后离开小区的车辆花费时间 363.4 秒。

根据汽车的出行情况可以看出，当车辆之间间隔两个车位且在无外来车辆的干扰时，他们的出行将不互相干扰，避免了拥堵和额外的等待时间。因此对车位进行划区域分块分配可以加快居民的出行，缓解高峰时期的拥堵。

模型评价与改进

模型二对模型一进行了完善，通过对车位分块规划，，将同一时间来车库的居民分散开，不同区域的车位相互干扰程度减少。同时，不同区域车位到电梯（楼梯）口的距离不同导致从同一时间从电梯（楼梯）出发的居民到达车位的时间间隔不同，这样就错开了居民车出库的时间，从而提高了交通的流畅程度，避免了上下班高峰时的拥挤程度。

在模型二中，我们对居民出发的先后顺序进行了标号，但是，我们并不知道是哪一位居民出行的先后顺序，我们需要改进。

4.1.3 模型三　车位分布与楼层高度模型

目前，高层住宅居民主要靠电梯上下楼层，住在同一单元的居民，居住楼层越高，搭乘楼梯所耗费的时间就越长。由于电梯运行方案采用上下行的方式，在高峰时段，居民出行的先后顺序是与楼层高度有关系的。当每个楼层都有人需要下楼时，较高层的居民优先登上下行的电梯，而低层经常遇到电梯满载的情况。在这种关系下，我们在模型二中，对居民的标号就与楼层联系起来了。住在 1-4 楼的居民按顺序分别标号为 1-8，住在最高层的两户居民编号记为 9 和 10，随着楼层的递减，居民的编号就依次增大。一般情况下同一楼层有两户居民，我们认为同一楼层的两户居民出行没有影响，比如最低楼层的两位居民 1 与 2 是没有区

别的。

我们研究的是人流量输送高峰时段，即在所有楼层居民的上班时间相同的假设下进行分析的。

符号说明：

T_W	电梯开关侧时间之和
T_k	人员进入时间
T_l	离开电梯时间
V	电梯运行平均速度
H	每层高度
Z	电梯满载荷量/人
T_{Pi}	当前等待的最高层
C	第i趟等待电梯层数之和
j	有效开侧次数
T_{oi}	电梯运行第i个周期需要的时间

上行：

$$T_{di} = \frac{H(T_{pi} - 1)}{V}$$

下行：

$$T_{ui} = \begin{cases} T_w(C_i + 1) + jT_k + T_l + \dfrac{H(T_{pi} - 1)}{V} \\ T_w(C_i + 1) + (j - 1)T_k + T_l + \dfrac{H(T_{pi} - 1)}{V} \quad i\text{为最后一次} \end{cases} \qquad 【5】$$

$$T_{oi} = T_{di} + T_{ui} \qquad 【6】$$

相关算法程序见附录。

到此为止，我们就建立了车位与出行人循序，出行人顺序与楼层之间的关系，从而找到了车位与居民之间的联系。

4.2 问题 2

首先需要声明的是附件 1 中的车位编号是不连续的，为了便于后续的建模、编程和分析，我们对车位进行了重新编号（详情见附件 1 的黑色编号）并且在之后问题 3 的分析和最后的结论中均使用这一编号。

考虑人流量的极限情况，即早晚高峰时期所有居民都使用私家车，所有车位的车都需出库。根据模型 1 的假设，此时东西两侧各 68 个人要去 136 个车位取车，即每个人取一辆车，每辆车均由一个人驾驶，因此这属于指派问题。对于从东侧$(i = 1)$或西侧$(i = 2)$出来的第j个人到和不到第k号车位取车的两种情况，可设计 0-1 变量。令

$$x_{ijk} = \begin{cases} 0, \\ \quad i = 1,2, \quad j = 1,2,\cdots 68, \quad k = 1,2,\cdots 136. \\ 1, \end{cases} \qquad 【7】$$

其中$x_{ijk}=0$表示从东侧$(i=1)$或西侧$(i=2)$出来的第j个人不去第k号车位取车；$x_{ijk}=1$表示从东侧$(i=1)$或西侧$(i=2)$出来的第j个人去第k号车位取车。

为了保证所有人取车的时间总和最短，所有人从电梯口出来到停车位取车这一过程步行的路程总和也应该最短。因此，目标函数就是求最短的总路程，表述为：

$$\min\ S=\sum_{i=1}^{2}\sum_{j=1}^{68}\sum_{k=1}^{136}x_{ijk}\cdot d_{ijk} \qquad 【8】$$

其中，S表示所有人走的路程总和，d_{ijk}从东侧$(i=1)$或西侧$(i=2)$出来的第j个人到第k号车位的距离。该距离可以用 Floyd 算法得出。

约束条件为：

1）每个人只能去一个停车位取车，即

$$\sum_{k=1}^{136}x_{ijk}=1,\ \ i=1,2,\ \ j=1,2,\cdots 68. \qquad 【9】$$

2）每个停车位的车只能由一个人驾驶，即

$$\sum_{i=1}^{2}\sum_{j=1}^{68}x_{ijk}=1,\quad k=1,2,\cdots 136. \qquad 【10】$$

综上，在所有居民的路程总和最短的前提下，实现高峰时期通畅出行的模型为：

$$\min\ S=\sum_{i=1}^{2}\sum_{j=1}^{68}\sum_{k=1}^{136}x_{ijk}\cdot d_{ijk} \qquad 【11】$$

$$\text{s.t.}\begin{cases}\sum_{k=1}^{136}x_{ijk}=1,\ \ i=1,2,\ \ j=1,2,\cdots 68,\\ \sum_{i=1}^{2}\sum_{j=1}^{68}x_{ijk}=1,\quad k=1,2,\cdots 136,\\ x_{ijk}\in\{0,1\}\end{cases} \qquad 【12】$$

利用 MATLAB 软件编程和在附件 1 中测得的 1 单元和 2 单元两侧出口到各车位的距离，最后可以得到若干组解，这些解的共同特点是总路程相同，均为 3464.48 米。

为了得到最优的车位分配方案，在此基础上，再利用模型 2 求解，进一步做 0-1 规划，增加约束条件“为先从居民楼出来的居民分配比较近的车位，后从居民楼出来的居民分配比较远的车位”。这样便保证了先从居民楼出来的人和后从居民楼出来的人之间有足够的时间差，这个时间差可以保证前者率先开车离开车位，避免之后造成拥堵，从而在所有人走的路程总和最短的前提下，保

证了高峰时期居民能通畅地出行。新的约束条件如下：

$$\sum_{k=1}^{136} x_{ijk} \cdot d_{ijk} \le \sum_{k=1}^{136} x_{i,j+1,k} \cdot d_{i,j+1,k}, \qquad i = 1,2, \qquad j = 1,2,\cdots 67 \qquad \textbf{【13】}.$$

综上，在所有居民的路程总和最短的前提下，实现高峰时期通畅出行的模型为[4]：

$$\min \ S = \sum_{i=1}^{2} \sum_{j=1}^{68} \sum_{k=1}^{136} x_{ijk} \cdot d_{ijk} \qquad \textbf{【14】}$$

$$\text{s.t.} \begin{cases} \sum_{k=1}^{136} x_{ijk} = 1, \ \ i = 1,2, \ \ j = 1,2,\cdots 68, \\ \sum_{i=1}^{2} \sum_{j=1}^{68} x_{ijk} = 1, \quad k = 1,2,\cdots 136, \\ \sum_{k=1}^{136} x_{ijk} \cdot d_{ijk} \le \sum_{k=1}^{136} x_{i,j+1,k} \cdot d_{i,j+1,k}, \qquad i = 1,2, \qquad j = 1,2,\cdots 67, \\ x_{ijk} \in \{0,1\}. \end{cases} \qquad \textbf{【15】}$$

利用 Lingo.11 软件编程[5]求解，经模型优化后，所有居民从电梯(楼梯)口出来到停车位取车这一过程步行的最短路程总和为 3464.48 米。且该停车位分布方案保证了高峰时期居民能通畅地出行。

现将附件 1 中的原停车位分布方案和经模型优化的停车位分布方案做对比，如表 4.2.1。从以下两个方面利用问题 1 的模型对前者作分析，并评价其合理性。

表 4.2.1

		附件 1 的停车位分布方案	经模型优化的停车位分布方案	优化后减少的路程
总路程 S/m	1 单元	2863.41	1778.59	1084.81
	2 单元	1640.40	1685.89	-45.49
	1、2 单元	4503.81	3464.48	1039.33
平均路程 $\bar{S}/m$	1 单元	21.05	13.08	7.98
	2 单元	12.06	12.40	-0.33
	1、2 单元	33.12	25.47	7.64

单人最长路程 S_{max}/m	1 单元	70.22	45.11	25.12
	2 单元	41.42	49.08	-7.66
	1、2 单元	70.22	49.08	21.14

1)所有居民步行取车花费的总时间和平均时间：

好的停车位分布方案需要保证居民的取车步行时间尽量的短。在此，对两种方案所有人取车步行总路程S与平均路程$\bar{S}$进行对比，分析知优化后的总路程为 3464.48 m，相比原方案缩短了 1084.81 m；优化后每人步行的平均路程为 25.47m，相比原方案缩短了 7.98 m。取人的平均步行速度为$1m/s$，则在总时间上和平均时间上分别节省了约 18 分钟和 8 秒。

2)居民全部驾车离开停车场的时间：

所有居民全部驾车离开停车场的时间是有最后一位离开停车场的居民所用的时间决定的，因此有必要研究单人取车步行的最长路程S_{max}。分析知原方案单人取车步行的最长路程为 70.22 m，而优化后为 49.08 m，相对缩短了 21.14 m。取人的平均步行速度为$1m/s$，则在居民全部驾车离开停车场的时间上缩短了约 21 秒。

综上分析，附件 1 中的原停车位分布方案不合理，因为该方案无论是在所有居民步行取车花费的总时间上和还是在居民全部驾车离开停车场的时间上均未做到最优化。

4.3 问题 3

针对附件 1 中的原停车位分布方案的不足，我们以问题 1 中建立的数学模型对停车位进行重新规划。

基本假设

1 居民楼中 1~4 层居民在上下班人流量高峰时期采用走楼梯的方式上下楼，其余楼层居民均使用电梯上下楼；

2 电梯满载量 15 人，每户均一人出门。

表 4.3.1: 电梯每次承载的居民所在楼层

第一次	34	33	32	31	30	29	28	27
第二次	27	26	25	24	23	22	21	20
第三次	19	18	17	16	15	14	13	12
第四次	12	11	10	9	8	7	6	5

经过模型计算模型求得，第一次与第二次电梯完成一次输送的时间间隔为 103 秒，第二次与第三次电梯完成一次输送的时间间隔为 79 秒，第三次与第四次电梯完成一次输送的时间间隔为 58 秒，第四次与第五次电梯完成一次输送的时间间隔为 24 秒。

由表 4.3.1 可以看出当所有人同时等电梯时，27~34 层居民最先下来，5~12 层居民最后下楼。（注：住在 27 层楼的居民分两次下楼）

运行问题 2 中的 Lingo 程序，并将运行结果进行简单整理：得出居民从楼中出来的先后顺序与最优化车位分布的车位号之间的对应关系如表 4.3.2。

表 4.3.2:　车位分布表

Variable	Value	d_{ijk}/m	Variable	Value	d_{ijk}/m
x(1,1,80)	1	10.45	x(2,1,59)	1	5.01
x(1,2,79)	1	10.58	x(2,2,60)	1	5.54
x(1,3,81)	1	11.00	x(2,3,73)	1	5.55
x(1,4,78)	1	11.30	x(2,4,61)	1	6.91
x(1,5,82)	1	12.01	x(2,5,72)	1	7.24
x(1,6,77)	1	12.44	x(2,6,71)	1	9.25
x(1,7,83)	1	13.96	x(2,7,70)	1	12.24
x(1,8,76)	1	14.52	x(2,8,69)	1	14.50
x(1,9,95)	1	14.64	x(2,9,32)	1	15.34
x(1,10,94)	1	14.78	x(2,10,33)	1	15.52
x(1,11,96)	1	14.90	x(2,11,46)	1	15.66
x(1,12,86)	1	15.58	x(2,12,34)	1	16.06
x(1,13,84)	1	15.66	x(2,13,93)	1	16.22
x(1,14,100)	1	15.85	x(2,14,45)	1	16.36
x(1,15,75)	1	16.29	x(2,15,68)	1	16.80
x(1,16,101)	1	16.91	x(2,16,111)	1	17.33
x(1,17,85)	1	17.53	x(2,17,44)	1	17.36
x(1,18,115)	1	17.91	x(2,18,110)	1	17.95
x(1,19,74)	1	18.21	x(2,19,109)	1	18.85
x(1,20,102)	1	18.23	x(2,20,43)	1	19.16
x(1,21,53)	1	21.21	x(2,21,92)	1	19.51
x(1,22,52)	1	21.30	x(2,22,67)	1	20.00
x(1,23,54)	1	21.47	x(2,23,42)	1	20.69
x(1,24,51)	1	21.69	x(2,24,19)	1	20.85
x(1,25,55)	1	21.98	x(2,25,108)	1	21.18
x(1,26,114)	1	22.00	x(2,26,18)	1	21.38
x(1,27,50)	1	22.32	x(2,27,91)	1	21.91
x(1,28,56)	1	23.08	x(2,28,17)	1	22.16
x(1,29,49)	1	23.57	x(2,29,66)	1	22.34

x(1,30,113)	1	24.05	x(2,30,41)	1	22.38
x(1,31,57)	1	24.14	x(2,31,107)	1	22.56
x(1,32,48)	1	24.72	x(2,32,99)	1	22.76
x(1,33,58)	1	25.37	x(2,33,16)	1	23.59
x(1,34,116)	1	25.77	x(2,34,106)	1	24.10
x(1,35,47)	1	26.03	x(2,35,90)	1	24.31
x(1,36,112)	1	26.16	x(2,36,65)	1	24.70
x(1,37,26)	1	26.50	x(2,37,98)	1	24.85
x(1,38,25)	1	26.57	x(2,38,15)	1	24.86
x(1,39,27)	1	26.70	x(2,39,40)	1	24.90
x(1,40,117)	1	26.71	x(2,40,105)	1	25.88
x(1,41,24)	1	26.88	x(2,41,14)	1	26.28
x(1,42,28)	1	27.12	x(2,42,39)	1	26.83
x(1,43,23)	1	27.39	x(2,43,97)	1	26.99
x(1,44,118)	1	27.83	x(2,44,89)	1	27.61
x(1,45,29)	1	28.02	x(2,45,104)	1	27.74
x(1,46,22)	1	28.42	x(2,46,64)	1	27.95
x(1,47,30)	1	28.89	x(2,47,13)	1	28.45
x(1,48,21)	1	29.38	x(2,48,38)	1	29.67
x(1,49,31)	1	29.93	x(2,49,103)	1	29.67
x(1,50,20)	1	30.49	x(2,50,88)	1	30.00
x(1,51,119)	1	31.57	x(2,51,12)	1	30.16
x(1,52,120)	1	32.52	x(2,52,63)	1	30.32
x(1,53,123)	1	37.63	x(2,53,37)	1	31.68
x(1,54,122)	1	37.69	x(2,54,11)	1	31.96
x(1,55,124)	1	37.77	x(2,55,87)	1	32.40
x(1,56,121)	1	37.91	x(2,56,62)	1	32.70
x(1,57,125)	1	38.06	x(2,57,36)	1	33.81
x(1,58,126)	1	38.70	x(2,58,10)	1	34.55
x(1,59,127)	1	39.34	x(2,59,35)	1	35.96
x(1,60,128)	1	40.10	x(2,60,9)	1	36.50
x(1,61,131)	1	42.92	x(2,61,8)	1	38.51
x(1,62,130)	1	42.97	x(2,62,4)	1	39.81
x(1,63,132)	1	43.05	x(2,63,7)	1	41.94
x(1,64,129)	1	43.17	x(2,64,6)	1	43.57
x(1,65,133)	1	43.30	x(2,65,5)	1	45.26
x(1,66,134)	1	43.87	x(2,66,3)	1	46.04
x(1,67,135)	1	44.42	x(2,67,2)	1	47.53
x(1,68,136)	1	45.11	x(2,68,1)	1	49.08

注： $x(i,j,k)$即涵盖了车位分布情况的信息，i代表两个不同的单元（$i=1$代表 1 单元的居民；$i=2$代表 2 单元的居民），$j=1,2\cdots 68$代表每个单元的居民按出来的先后顺序进行排序，$k=1,2\cdots 136$代表 136 个停车位（为了建模和编程

方便，已经在附件 1 中对车位按 1~136 重新标号)。利用 Lingo 的 Solution 功能只保留了变量$x(i,j,k)=1$的情况。而 d 代表取车需步行的距离。例如，“$x(1,1,80)=1$”是指在最优分配方案中，从 1 单元出口出来的第 1 个人应该去第 80 号停车位，取车所需的步行距离为 10.45m；“$x(2,68,1)=1$” 是指从 2 单元出口出来的第 68 个人应该去第 1 号停车位，取车所需的步行距离为 49.08m。
根据之前模型的假设，得出居民从楼中出来的先后顺序与其房间号的对应关系如表 4.3.3。

表 4.3.3：居民从楼中出来的先后顺序与其房间号的对应关系

1 单元居民出来的先后顺序	1 单元房间号	1 单元居民出来的先后顺序	1 单元房间号	2 单元居民出来的先后顺序	2 单元房间号	2 单元居民出来的先后顺序	2 单元房间号
1	7-1-101	35	7-1-2101	1	7-2-101	35	7-2-2101
2	7-1-102	36	7-1-2102	2	7-2-102	36	7-2-2102
3	7-1-201	37	7-1-2001	3	7-2-201	37	7-2-2001
4	7-1-202	38	7-1-2002	4	7-2-202	38	7-2-2002
5	7-1-301	39	7-1-1901	5	7-2-301	39	7-2-1901
6	7-1-302	40	7-1-1902	6	7-2-302	40	7-2-1902
7	7-1-401	41	7-1-1801	7	7-2-401	41	7-2-1801
8	7-1-402	42	7-1-1802	8	7-2-402	42	7-2-1802
9	7-1-3401	43	7-1-1701	9	7-2-3401	43	7-2-1701
10	7-1-3402	44	7-1-1702	10	7-2-3402	44	7-2-1702
11	7-1-3301	45	7-1-1601	11	7-2-3301	45	7-2-1601
12	7-1-3302	46	7-1-1602	12	7-2-3302	46	7-2-1602
13	7-1-3201	47	7-1-1501	13	7-2-3201	47	7-2-1501
14	7-1-3202	48	7-1-1502	14	7-2-3202	48	7-2-1502
15	7-1-3101	49	7-1-1401	15	7-2-3101	49	7-2-1401
16	7-1-3102	50	7-1-1402	16	7-2-3102	50	7-2-1402
17	7-1-3001	51	7-1-1301	17	7-2-3001	51	7-2-1301
18	7-1-3002	52	7-1-1302	18	7-2-3002	52	7-2-1302
19	7-1-2901	53	7-1-1201	19	7-2-2901	53	7-2-1201
20	7-1-2902	54	7-1-1202	20	7-2-2902	54	7-2-1202
21	7-1-2801	55	7-1-1101	21	7-2-2801	55	7-2-1101
22	7-1-2802	56	7-1-1102	22	7-2-2802	56	7-2-1102
23	7-1-2701	57	7-1-1001	23	7-2-2701	57	7-2-1001
24	7-1-2702	58	7-1-1002	24	7-2-2702	58	7-2-1002
25	7-1-2601	59	7-1-901	25	7-2-2601	59	7-2-901
26	7-1-2602	60	7-1-902	26	7-2-2602	60	7-2-902

27	7-1-2501	61	7-1-801	27	7-2-2501	61	7-2-801
28	7-1-2502	62	7-1-802	28	7-2-2502	62	7-2-802
29	7-1-2401	63	7-1-701	29	7-2-2401	63	7-2-701
30	7-1-2402	64	7-1-702	30	7-2-2402	64	7-2-702
31	7-1-2301	65	7-1-601	31	7-2-2301	65	7-2-601
32	7-1-2302	66	7-1-602	32	7-2-2302	66	7-2-602
33	7-1-2201	67	7-1-501	33	7-2-2201	67	7-2-501
34	7-1-2202	68	7-1-502	34	7-2-2202	68	7-2-502

综合表 4.3.2 和表 4.3.3，得出居民的房间号与最优化车位分布的车位号之间的对应关系如表 4.3.4。

表 4.3.4

房间号	车位号	房间号	车位号	房间号	车位号	房间号	车位号
7-1-101	80	7-1-2101	47	7-2-101	59	7-2-2101	90
7-1-102	79	7-1-2102	112	7-2-102	60	7-2-2102	65
7-1-201	81	7-1-2001	26	7-2-201	73	7-2-2001	98
7-1-202	78	7-1-2002	25	7-2-202	61	7-2-2002	15
7-1-301	82	7-1-1901	27	7-2-301	72	7-2-1901	40
7-1-302	77	7-1-1902	117	7-2-302	71	7-2-1902	105
7-1-401	83	7-1-1801	24	7-2-401	70	7-2-1801	14
7-1-402	76	7-1-1802	28	7-2-402	69	7-2-1802	39
7-1-3401	95	7-1-1701	23	7-2-3401	32	7-2-1701	97
7-1-3402	94	7-1-1702	118	7-2-3402	33	7-2-1702	89
7-1-3301	96	7-1-1601	29	7-2-3301	46	7-2-1601	104
7-1-3302	86	7-1-1602	22	7-2-3302	34	7-2-1602	64
7-1-3201	84	7-1-1501	30	7-2-3201	93	7-2-1501	13
7-1-3202	100	7-1-1502	21	7-2-3202	45	7-2-1502	38
7-1-3101	75	7-1-1401	31	7-2-3101	68	7-2-1401	103
7-1-3102	101	7-1-1402	20	7-2-3102	111	7-2-1402	88
7-1-3001	85	7-1-1301	119	7-2-3001	44	7-2-1301	12
7-1-3002	115	7-1-1302	120	7-2-3002	110	7-2-1302	63
7-1-2901	74	7-1-1201	123	7-2-2901	109	7-2-1201	37
7-1-2902	102	7-1-1202	122	7-2-2902	43	7-2-1202	11
7-1-2801	53	7-1-1101	124	7-2-2801	92	7-2-1101	87
7-1-2802	52	7-1-1102	121	7-2-2802	67	7-2-1102	62
7-1-2701	54	7-1-1001	125	7-2-2701	42	7-2-1001	36
7-1-2702	51	7-1-1002	126	7-2-2702	19	7-2-1002	10
7-1-2601	55	7-1-901	127	7-2-2601	108	7-2-901	35
7-1-2602	114	7-1-902	128	7-2-2602	18	7-2-902	9
7-1-2501	50	7-1-801	131	7-2-2501	91	7-2-801	8
7-1-2502	56	7-1-802	130	7-2-2502	17	7-2-802	4

7-1-2401	49	7-1-701	132	7-2-2401	66	7-2-701	7
7-1-2402	113	7-1-702	129	7-2-2402	41	7-2-702	6
7-1-2301	57	7-1-601	133	7-2-2301	107	7-2-601	5
7-1-2302	48	7-1-602	134	7-2-2302	99	7-2-602	3
7-1-2201	58	7-1-501	135	7-2-2201	16	7-2-501	2
7-1-2202	116	7-1-502	136	7-2-2202	106	7-2-502	1

更直观的结果呈现在了下页的 PDF 上，上面展示了原车位编号、新车位编号（为了建模方便）和居民房间号的对应关系

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北

7#（136）

排风机房 39.65

梯 梯16 30.21

过道 3478.95

空

1—1161 7-2-502 1	1—1160 7-2-501 2	1—1159 7-2-602 3
1—1334 7-2—601 5	1—1335 7-2—702 6	1—1336 7-2-701 7

1—1337 7-2-802 4

1—1424 7-2—801 8	1—1423 7-2—902 9	1—1422 7-2—1002 10
1—1554 7-2-901 35	1—1555 7-2—1001 36	1—1556 7-2—1201 37

1—1421 7-2—1202 11	1—1420 7-2—1301 12	1—1419 7-2—1501 13
1—1557 7-2-1501 38	1—1558 7-2-1802 39	1—1559 7-2-1901 40

7—2—1801 14	7—2—2002 15	7—2—2201 16
7-2-2402 41	7-2-2701 42	7-2-2902 43

7—2—2502 17	7—2—2602 18	7—2—2702 19
7-2-3001 44	7-2-3202 45	7-2-3301 46

1—1566 7-2—3401 32	1—1567 7-2—3402 33	1—1568 7-2—3302 34

1—1412 7-1-1402 20	1—1411 7-1-1502 21	1—1410 7-1-1602 22
1—1569 7-1-2101 47	1—1570 7-1—2302 48	1—1571 7-1-2401 49

1—1409 7-1-1701 23	1—1408 7-1-1801 24	1—1407 7-1-2002 25
1—1572 7-1-2501 50	1—1573 7-1-2702 51	1—1574 7-1-2802 52

1—1406 7-1-2001 26	1—1405 7-1-1901 27	1—1404 7-1-1802 28
1—1575 7-1-2801 53	1—1576 7-1-2701 54	1—1577 7-1-2601 55

1—1403 7-1-1601 29	1—1402 7-1-1501 30	1—1401 7-1-1401 31
1—1578 7-1-2502 56	1—1579 7-1-2301 57	1—1580 7-1-2201 58

1—1643 7-2-1102 62	1—1642 7-2-1302 63	1—1641 7-2-1602 64
1—1817 7-2-1101 87	1—1818 7-2-1402 88	1—1819 7-2-1702 89

1—1640 7-2-2102 65	1—1639 7-2-2401 66	1—1638 7-2-2802 67
1—1820 7-2-2101 90	1—1821 7-2-2501 91	1—1822 7-2-2801 92

7-2-3101 68	7-2-402 69	7-2-401 70
1—1823 7-2-3201 93		

7—2—302 71	7-2-301 72	7-2-201 73

7-2-101 59	7—2—102 60	7-2-202 61

7-1—2901 74	7-1-3101 75	7-1-402 76

7-1-302 77	7-1-202 78	7-1-102 79

7-1-101 80	7-1-201 81	7-1-301 82

7-1-401 83	7-1-3201 84	7-1-3001 85

1—1824 7-1-3302 86

1—1862 7—1—3402 94
1—1863 7—1—3401 95
1—1864 7—1—3301 96

1—1865 7-1-3202 100
1—1866 7-1-3202 101
1—1867 7-1-2902 102

1—1870 7-2-1701 97	1—1869 7-2-2001 98	1—1868 7-2-2302 99
2—173 7-2-1401 103	2—174 7-2-1601 104	2—175 7-2-1902 105

2—176 7-2 2202 106	2—177 7-2-2301 107	2—178 7-2-2601 108

2—179 7-2-2901 109	2—180 17-2-3002 110	2—181 7-2-3102 111

2—182 7-1-2102 112	2—183 7-1-2402 113	2—184 7-1-2602 114

2—185 7-1-3002 115

2—188 7-1-2202 116	2—187 7-1-1902 117	2—186 7-1-1702 118
	2—1312 7 1-1301 119	2—1313 7-1-1302 120

2—1338 7-1-1102 121	2—1337 7-1-1202 122	
2—1484 7-1-702 129	2—1485 7-1-802 130	

2—1336 7-1-1201 123	2—1335 7-1-1101 124	2—1334 7-1-1001 125
2—1486 7-1—801 131	2—1487 7—1—701 132	2—1488 7-1-601 133

2—1333 7-1-1002 126	2—1332 7-1-901 127	2—1331 7-1-902 128
2—1489 7-1-602 134	2—1490 7-1—501 135	2—1491 7-1—502 136

附录

模型一 图 4.1.1 与 4.1.2 图形代码

```
data1=2*ones(200,2)+2*randn(200,2);
data2=-2*ones(200,2)+2*randn(200,2);
data=[data1;data2];
num=size(data,1);
label=zeros(num,1);
rand_num=ceil(rand*num/2);
m1=data(rand_num,:);

m2=data(mod(rand_num+200,100),:);  %产生两个随机中心

iter=1;
while (iter<=100)

    for i=1:num   %初始划分

        if dist(m1,data(i,:)')<dist(m2,data(i,:)')
            label(i)=1;
        else
            label(i)=2;
        end
    end
    m1=mean(data(label==1,:),1);
    m2=mean(data(label==2,:),1);
    iter=iter+1;
end
figure(2);
plot(data(find(label-2),1),data(find(label-
2),2),'b+','markersize',6);
hold on;
plot(data(find(label-1),1),data(find(label-
1),2),'r.','markersize',6);
```

car_init

```
function [ p] = car_init( ren1car,i,car_rol,car_row,ceta1,ceta2 )
%UNTITLED3 Summary of this function goes here
%     Detailed explanation goes here
p(1,:)=[ren1car(1)+car_rol*cos(ceta1+i),ren1car(2)+car_rol*sin(ceta1+i)];
p(2,:)=[ren1car(1)+car_rol*cos(-ceta1+i),ren1car(2)+car_rol*sin(-ceta1+i)];
p(4,:)=[ren1car(1)+car_row*cos(ceta2+i),ren1car(2)+car_row*sin(ceta2+i)];
p(3,:)=[ren1car(1)+car_row*cos(-ceta2+i),ren1car(2)+car_row*sin(-ceta2+i)];
p(5,:)=[ren1car(1)+car_rol*cos(ceta1+i),ren1car(2)+car_rol*sin(ceta1+i)];      %一号
车的端点
end
```

```
down_car
ren(mark,:)=[0,0];                                          %二号人位置坐标
rencar(mark,:)=[ren_go(mark,1)+place_w/2-r1,ren_go(mark,2)];      %二号车的倒车旋转点坐标
come(mark)=1;                       %步行标志 1 为是
backwards(mark)=0;                  %倒车标志位   1 为是
car(mark)=0;                        %驾车前进标志位 1 为是
angle(mark)=0;
point(:,:,mark)= car_init( rencar(mark,:),angle(mark),car_rol,car_row,ceta1,ceta2 );   %二号车的端点

four_dian
function [ four ] = four_dian( point1 )
%UNTITLED3 Summary of this function goes here
%     Detailed explanation goes here
point2=[point1(1)+2.4,point1(2)];
point3=[point1(1)+2.4,point1(2)+5.3];
point4=[point1(1),point1(2)+5.3];
four=[point1;point2;point3;point4;point1];
plot(four(:,1),four(:,2),'r');
end

road3
clear
clc
n=0.2;                          %时间刻度
over_car=0;                     %已经离开的车辆
place_l=5.3;                    %停车位长度
place_w=2.4;                    %停车位宽度
r1=6;                           %倒车转弯半径
k=8;                            %距离
v_p=1.5;                        %人的速度
v_car=4;                        %汽车速度
car_l=4.8;                      %汽车的长度
car_w=1.8;                      %汽车的宽度
road_w=r1;                      %路的宽度
l_total=80;                     %路的长度
road=[
      0,road_w/2;
      0,-road_w/2;
      l_total,-road_w/2;
      l_total,road_w/2;
      0,road_w/2];
```

```
plot(road(:,1),road(:,2));
hold;
car_rol=sqrt((car_l/2)*(car_l/2)+(r1-(place_w-car_w)/2)*(r1-(place_w-car_w)/2));
car_row=sqrt((car_l/2)*(car_l/2)+(r1-(place_w+car_w)/2)*(r1-(place_w+car_w)/2));
ceta1=atan((car_l/2)/(r1-(place_w-car_w)/2));
ceta2=atan((car_l/2)/(r1-(place_w+car_w)/2));
for i=1:30
    point_up(i,:)=[k+place_w*(i-1),road_w/2];
    pointup(:,:,i)=four_dian ( point_up(i,:) );
end
for i=1:30
    point_down(i,:)=[k+place_w*(i-1),-road_w/2-place_l];
    pointdown(:,:,i)=four_dian ( point_down(i,:) );
end
axis([0,160,-40,40]);
axis equal
%以上为停车场预处理
m=60;                          %总人数
m_up=30;
m_down=30;

place_up=[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,2
8,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50];    %上排车
辆分布图
place_down=[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,2
7,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50];  % 下 排
车辆分布图
for i=1:m_up
    mark=i;
    ren_go(mark,:)=[pointup(2,1,place_up(i))-place_w/2,road_w/2+place_l/2];    %
上排人步行目的地
    up_car;
    h1(mark)=plot(ren(mark,1),ren(mark,2),'ko');
    switch mod(i,5)
        case 1
            h2(mark)=fill(point(:,1,mark),point(:,2,mark),'r');
        case 2
            h2(mark)=fill(point(:,1,mark),point(:,2,mark),'y');
        case 3
            h2(mark)=fill(point(:,1,mark),point(:,2,mark),'c');
        case 4
            h2(mark)=fill(point(:,1,mark),point(:,2,mark),'b');
        case 0
            h2(mark)=fill(point(:,1,mark),point(:,2,mark),'g');
```

```
            otherwise
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'w');
        end
end
  for i=1:m_down
        mark=i+m_up;
        ren_go(mark,:)=[pointup(2,1,place_down(i))-place_w/2,-road_w/2-
place_l/2];     %下排人步行目的地
        down_car;
        h1(mark)=plot(ren(mark,1),ren(mark,2),'ko');
        switch mod(i,5)
            case 0
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'r');
            case 4
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'y');
            case 3
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'c');
            case 2
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'b');
            case 1
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'g');
            otherwise
                h2(mark)=fill(point(:,1,mark),point(:,2,mark),'w');
        end
end


for t=0:n:450
        for mark=1:m
           if(ren_go(mark,2)>0)
           if(come(mark))                              %上排车
              if(ren(mark,1)<ren_go(mark,1)-v_p*n)
                    ren(mark,1)=ren(mark,1)+v_p*n;
              else
                    ren(mark,1)=ren_go(mark,1);
                    if(ren(mark,2)<ren_go(mark,2))
                        ren(mark,2)=ren(mark,2)+v_p*n;
                    else
                        ren(mark,2)=ren_go(mark,2);
                        v(m+1,mark)=1;
                        for i=1:m
                            if(i~=mark)
                                if(backwards(i))
                                  v(i,mark)=((rencar(mark,1)-
```

```
rencar(i,1))>2*place_w+2||(rencar(mark,1)-rencar(i,1))<-(r1+(car_l+car_w)/2));
                                elseif(car(i))
                                    v(i,mark)=((rencar(mark,1)-
rencar(i,1))>15||(rencar(mark,1)-rencar(i,1))<-(r1+(car_l+car_w)/2));
                                else
                                    v(i,mark)=1;
                                end
                                  v(m+1,mark)=v(m+1,mark)*v(i,mark);
                            end
                        end
                        if(v(m+1,mark))
                            come(mark)=0;
                            backwards(mark)=1;
                        end
                    end
                end
                set(h1(mark),'xdata',ren(mark,1));
                set(h1(mark),'ydata',ren(mark,2));
            elseif(backwards(mark))
                ren(mark,:)=[0,0];
                set(h1(mark),'xdata',ren(mark,1));
                set(h1(mark),'ydata',ren(mark,2));
                if(rencar(mark,2)>road_w/2+5.3/2-1.5)
                    rencar(mark,2)=rencar(mark,2)-n;
                else
                    if(angle(mark)>-pi/2)
                        if(angle(mark)<-pi/6)
                            angle(mark)=angle(mark)-pi/60;
                        else
                            angle(mark)=angle(mark)-pi/180;
                        end
                    else
                        backwards(mark)=0;
                        car(mark)=1;
                    end
                end
            else
                v(m+1,mark)=1;
                for i=1:m
                    if(i~=mark)
                        if(backwards(i))
                            v(i,mark)=((rencar(i,1)-
rencar(mark,1))>place_l+2||(rencar(i,1)-rencar(mark,1))<0);
                        elseif(car(i))
```

```
                        v(i,mark)=((rencar(i,1)-
rencar(mark,1))>2+place_l||(rencar(i,1)-rencar(mark,1))<-place_l);
                    else
                        v(i,mark)=1;
                    end
                    v(m+1,mark)=v(m+1,mark)*v(i,mark);
                end
            end
            if(v(m+1,mark))
                rencar(mark,1)=rencar(mark,1)+v_car*n;
            end
        end
        point(:,:,mark)=
car_init( rencar(mark,:),angle(mark),car_rol,car_row,ceta1,ceta2 );
        set(h2(mark),'xdata',point(:,1,mark));
        set(h2(mark),'ydata',point(:,2,mark));
        elseif(ren_go(mark,2)<0)
        if(come(mark))                          %下排车
            if(ren(mark,1)<ren_go(mark,1)-v_p*n)
                ren(mark,1)=ren(mark,1)+v_p*n;
            else
                ren(mark,1)=ren_go(mark,1);
                if(ren(mark,2)>ren_go(mark,2))
                    ren(mark,2)=ren(mark,2)-v_p*n;
                else
                    ren(mark,2)=ren_go(mark,2);
                    v(m+1,mark)=1;
                    for i=1:m
                        if(i~=mark)
                            if(backwards(i))
                              v(i,mark)=((rencar(mark,1)-
rencar(i,1))>2*place_w+2||(rencar(mark,1)-rencar(i,1))<-(r1+(car_l+car_w)/2));
                            elseif(car(i))
                                v(i,mark)=((rencar(mark,1)-
rencar(i,1))>15||(rencar(mark,1)-rencar(i,1))<-(r1+(car_l+car_w)/2));
                            else
                                v(i,mark)=1;
                            end
                              v(m+1,mark)=v(m+1,mark)*v(i,mark);
                        end
                    end
                    if(v(m+1,mark))
                        come(mark)=0;
                        backwards(mark)=1;
```

```
                end
            end
        end
        set(h1(mark),'xdata',ren(mark,1));
        set(h1(mark),'ydata',ren(mark,2));
    elseif(backwards(mark))
        ren(mark,:)=[0,0];
        set(h1(mark),'xdata',ren(mark,1));
        set(h1(mark),'ydata',ren(mark,2));
        if(rencar(mark,2)<-(road_w/2+5.3/2-1.5))
            rencar(mark,2)=rencar(mark,2)+n;
        else
            if(angle(mark)<pi/2)
                if(angle(mark)>pi/6)
                    angle(mark)=angle(mark)+pi/60;
                else
                    angle(mark)=angle(mark)+pi/180;
                end
            else
                backwards(mark)=0;
                car(mark)=1;
            end
        end
    else
        v(m+1,mark)=1;
        for i=1:m
            if(i~=mark)
                if(backwards(i))
                    v(i,mark)=((rencar(i,1)-
rencar(mark,1))>place_l+2||(rencar(i,1)-rencar(mark,1))<0);
                elseif(car(i))
                    v(i,mark)=((rencar(i,1)-
rencar(mark,1))>2+place_l||(rencar(i,1)-rencar(mark,1))<-place_l);
                else
                    v(i,mark)=1;
                end
                v(m+1,mark)=v(m+1,mark)*v(i,mark);
            end
        end
        if(v(m+1,mark))
            rencar(mark,1)=rencar(mark,1)+v_car*n;
        end
    end
    point(:,:,mark)=
```

```
car_init( rencar(mark,:),angle(mark),car_rol,car_row,ceta1,ceta2 );
      set(h2(mark),'xdata',point(:,1,mark));
      set(h2(mark),'ydata',point(:,2,mark));
         end
      end
      drawnow
      pause(0.1);
      judge(m+1)=0;
      for i=1:m
            judge(i)=(rencar(i,1)>l_total+car_l/2);
            judge(m+1)=judge(m+1)+judge(i);
      end
      if(judge(m+1)>over_car)
            cost(judge(m+1))=t;
            over_car=judge(m+1);
      end
end

up_car
ren(mark,:)=[0,0];                                          %一号人位置坐标
rencar(mark,:)=[ren_go(mark,1)+place_w/2-r1,ren_go(mark,2)];    %一号车的倒车旋转点坐标
come(mark)=1;                       %步行标志 1 为是
backwards(mark)=0;                  %倒车标志位  1 为是
car(mark)=0;                        %驾车前进标志位 1 为是
angle(mark)=0;
point(:,:,mark)= car_init( rencar(mark,:),angle(mark),car_rol,car_row,ceta1,ceta2 );  %一号车的
端点

dianti
clear
clc
z=15;  %电梯满载量
h=3;   %楼层高度
v=3;   %电梯运行平均速度
ti=2;  %人员进入花费时间
tl=8;  %离开电梯花费时间
tw=1;  %电梯开关门的时间和

teshu=0;
z_people=0;%电梯中人数
dengdai=[0,linspace(2,2,33)];
[ number_p,top,ceng,ceng_number] = chuli(dengdai);
i_max=ceil(number_p/z);        %  大于 x 的最小整数
td=zeros(1,i_max);
```

```
tu=zeros(1,i_max);
for k=1:i_max
    j=0;
    z_people=0;%电梯中人数
    td(k)=(top-1)*h/v;
    while(z_people<z)
        j=j+1;
        if(ceng(j)==0)
            teshu=1;
            break
        end
        z_people=z_people+dengdai(ceng(j));
    end

    for i=1:j-1
        dengdai(ceng(i))=0;
       fenceng(k,i)=ceng(i);
    end
    if(teshu==1)
        tu(k)=tw*(ceng_number+1)+(j-1)*ti+tl+(top-1)*h/v;
    else
       fenceng(k,j)=ceng(j);
        dengdai(ceng(j))=z_people-z;
        tu(k)=tw*(ceng_number+1)+j*ti+tl+(top-1)*h/v;
    end
    [ number_p,top,ceng,ceng_number] = chuli(dengdai);
end
t_total=td+tu;
```

lingo 11 程序结果

```
  Global optimal solution found.
  Objective value:                              3464.480
  Objective bound:                              3464.480
  Infeasibilities:                              0.000000
  Extended solver steps:                               0
  Total solver iterations:                             6


                       Variable           Value        Reduced Cost
                  X( 1, 1, 80)       1.000000           10.45
                  X( 1, 2, 79)       1.000000           10.58
                  X( 1, 3, 81)       1.000000           11.00
                  X( 1, 4, 78)       1.000000           11.30
                  X( 1, 5, 82)       1.000000           12.00
```

X(1, 6, 77)	1.000000	12.44
X(1, 7, 83)	1.000000	13.96
X(1, 8, 76)	1.000000	14.52
X(1, 9, 95)	1.000000	14.64
X(1, 10, 94)	1.000000	14.78
X(1, 11, 96)	1.000000	14.90
X(1, 12, 86)	1.000000	15.58
X(1, 13, 84)	1.000000	15.66
X(1, 14, 100)	1.000000	15.85
X(1, 15, 75)	1.000000	16.29
X(1, 16, 101)	1.000000	16.91
X(1, 17, 85)	1.000000	17.53
X(1, 18, 115)	1.000000	17.91
X(1, 19, 74)	1.000000	18.20
X(1, 20, 102)	1.000000	18.23
X(1, 21, 53)	1.000000	21.21
X(1, 22, 52)	1.000000	21.30
X(1, 23, 54)	1.000000	21.47
X(1, 24, 51)	1.000000	21.69
X(1, 25, 55)	1.000000	21.98
X(1, 26, 114)	1.000000	22.00
X(1, 27, 50)	1.000000	22.32
X(1, 28, 56)	1.000000	23.08
X(1, 29, 49)	1.000000	23.57
X(1, 30, 113)	1.000000	24.04
X(1, 31, 57)	1.000000	24.14
X(1, 32, 48)	1.000000	24.72
X(1, 33, 58)	1.000000	25.37
X(1, 34, 116)	1.000000	25.77
X(1, 35, 47)	1.000000	26.03
X(1, 36, 112)	1.000000	26.16
X(1, 37, 26)	1.000000	26.50
X(1, 38, 25)	1.000000	26.57
X(1, 39, 27)	1.000000	26.70
X(1, 40, 117)	1.000000	26.71
X(1, 41, 24)	1.000000	26.88
X(1, 42, 28)	1.000000	27.12
X(1, 43, 23)	1.000000	27.39
X(1, 44, 118)	1.000000	27.83
X(1, 45, 29)	1.000000	28.02
X(1, 46, 22)	1.000000	28.42
X(1, 47, 30)	1.000000	28.89
X(1, 48, 21)	1.000000	29.38
X(1, 49, 31)	1.000000	29.93

X(1, 50, 20)	1.000000	30.49
X(1, 51, 119)	1.000000	31.57
X(1, 52, 120)	1.000000	32.52
X(1, 53, 123)	1.000000	37.63
X(1, 54, 122)	1.000000	37.69
X(1, 55, 124)	1.000000	37.77
X(1, 56, 121)	1.000000	37.91
X(1, 57, 125)	1.000000	38.06
X(1, 58, 126)	1.000000	38.70
X(1, 59, 127)	1.000000	39.34
X(1, 60, 128)	1.000000	40.10
X(1, 61, 131)	1.000000	42.92
X(1, 62, 130)	1.000000	42.97
X(1, 63, 132)	1.000000	43.05
X(1, 64, 129)	1.000000	43.17
X(1, 65, 133)	1.000000	43.30
X(1, 66, 134)	1.000000	43.87
X(1, 67, 135)	1.000000	44.42
X(1, 68, 136)	1.000000	45.11
X(2, 1, 59)	1.000000	5.01
X(2, 2, 60)	1.000000	5.54
X(2, 3, 73)	1.000000	5.55
X(2, 4, 61)	1.000000	6.91
X(2, 5, 72)	1.000000	7.24
X(2, 6, 71)	1.000000	9.25
X(2, 7, 70)	1.000000	12.24
X(2, 8, 69)	1.000000	14.50
X(2, 9, 32)	1.000000	15.34
X(2, 10, 33)	1.000000	15.52
X(2, 11, 46)	1.000000	15.66
X(2, 12, 34)	1.000000	16.06
X(2, 13, 93)	1.000000	16.22
X(2, 14, 45)	1.000000	16.36
X(2, 15, 68)	1.000000	16.80
X(2, 16, 111)	1.000000	17.33
X(2, 17, 44)	1.000000	17.36
X(2, 18, 110)	1.000000	17.95
X(2, 19, 109)	1.000000	18.85
X(2, 20, 43)	1.000000	19.16
X(2, 21, 92)	1.000000	19.51
X(2, 22, 67)	1.000000	20.00
X(2, 23, 42)	1.000000	20.69
X(2, 24, 19)	1.000000	20.85
X(2, 25, 108)	1.000000	21.18

X(2, 26, 18)	1.000000	21.38
X(2, 27, 91)	1.000000	21.91
X(2, 28, 17)	1.000000	22.16
X(2, 29, 66)	1.000000	22.34
X(2, 30, 41)	1.000000	22.38
X(2, 31, 107)	1.000000	22.56
X(2, 32, 99)	1.000000	22.76
X(2, 33, 16)	1.000000	23.59
X(2, 34, 106)	1.000000	24.10
X(2, 35, 90)	1.000000	24.31
X(2, 36, 65)	1.000000	24.70
X(2, 37, 98)	1.000000	24.85
X(2, 38, 15)	1.000000	24.86
X(2, 39, 40)	1.000000	24.92
X(2, 40, 105)	1.000000	25.88
X(2, 41, 14)	1.000000	26.28
X(2, 42, 39)	1.000000	26.83
X(2, 43, 97)	1.000000	26.99
X(2, 44, 89)	1.000000	27.61
X(2, 45, 104)	1.000000	27.74
X(2, 46, 64)	1.000000	27.95
X(2, 47, 13)	1.000000	28.45
X(2, 48, 38)	1.000000	28.84
X(2, 49, 103)	1.000000	29.67
X(2, 50, 88)	1.000000	30.00
X(2, 51, 12)	1.000000	30.16
X(2, 52, 63)	1.000000	30.32
X(2, 53, 37)	1.000000	31.68
X(2, 54, 11)	1.000000	31.96
X(2, 55, 87)	1.000000	32.40
X(2, 56, 62)	1.000000	32.70
X(2, 57, 36)	1.000000	33.81
X(2, 58, 10)	1.000000	34.55
X(2, 59, 35)	1.000000	35.96
X(2, 60, 9)	1.000000	36.50
X(2, 61, 8)	1.000000	38.51
X(2, 62, 4)	1.000000	39.81
X(2, 63, 7)	1.000000	41.94
X(2, 64, 6)	1.000000	43.57
X(2, 65, 5)	1.000000	45.26
X(2, 66, 3)	1.000000	46.04
X(2, 67, 2)	1.000000	47.53
X(2, 68, 1)	1.000000	49.08

lingo 11 程序源代码

```
sets:
orientations/1..2/;!每栋楼分2个单元，"1"代表东侧的1单元，"2"代表西侧的2单元;
people/1..68/;!对各个单元中从电梯中出来到停车场的人按先后顺序进行标号;
locations/1..136/;!为了便于程序计算，从停车场的西北角到东南角将车位从1到136标
号;
link(orientations,people,locations):distance,x;
endsets
data:
distance=
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41   47.63 45.65 43.72 41.15  39.34  37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12   28.02 28.89 29.93 31.52 29.79
28.16  59.68  57.44  55.22  52.18 50.00 47.84 44.90 42.80 40.74 37.96
   35.99  34.08  26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98  23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
   46.30  43.97  40.77 38.45 36.15 33.00  30.73  28.48 18.21   16.29
14.52 12.44   11.30  10.58 10.45   11.00  12.01 13.96 15.66 17.53
   15.58  55.85  53.46  51.07  47.79  45.41  43.02  39.75  14.78
   14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23  48.81 46.48
   44.15  41.20 38.91   36.63  33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97   42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41   47.63 45.65 43.72 41.15  39.34  37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12   28.02 28.89 29.93 31.52 29.79
28.16  59.68  57.44  55.22  52.18 50.00 47.84 44.90 42.80 40.74 37.96
   35.99  34.08  26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98  23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
   46.30  43.97  40.77 38.45 36.15 33.00  30.73  28.48 18.21   16.29
14.52 12.44   11.30  10.58 10.45   11.00  12.01 13.96 15.66 17.53
   15.58  55.85  53.46  51.07  47.79  45.41  43.02  39.75  14.78
   14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23  48.81 46.48
   44.15  41.20 38.91   36.63  33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97   42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41   47.63 45.65 43.72 41.15  39.34  37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12   28.02 28.89 29.93 31.52 29.79
28.16  59.68  57.44  55.22  52.18 50.00 47.84 44.90 42.80 40.74 37.96
   35.99  34.08  26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98  23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
   46.30  43.97  40.77 38.45 36.15 33.00  30.73  28.48 18.21   16.29
14.52 12.44   11.30  10.58 10.45   11.00  12.01 13.96 15.66 17.53
```

15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11

70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47
21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
27.39 26.88 26.57 26.50 26.70 27.12 28.02 28.89 29.93 31.52 29.79
28.16 59.68 57.44 55.22 52.18 50.00 47.84 44.90 42.80 40.74 37.96
35.99 34.08 26.03 24.72 23.57 22.32 21.69 21.30 21.21 21.47

21.98 23.08 24.14 25.37 25.71 23.56 21.46 56.58 54.22 51.87 48.64
46.30 43.97 40.77 38.45 36.15 33.00 30.73 28.48 18.21 16.29
14.52 12.44 11.30 10.58 10.45 11.00 12.01 13.96 15.66 17.53
15.58 55.85 53.46 51.07 47.79 45.41 43.02 39.75 14.78
14.64 14.90 47.89 45.51 43.13 15.85 16.91 18.23 48.81 46.48
44.15 41.20 38.91 36.63 33.26 31.01 28.78 26.16 24.05 22.00
17.91 25.77 26.71 27.83 31.57 32.52 37.91 37.69 37.63 37.77 38.06
38.70 39.34 40.10 43.17 42.97 42.92 43.05 43.30 43.87 44.42 45.11
70.22 68.33 66.47 60.51 67.14 65.16 63.21 61.75 59.59 57.45 54.55
52.46 50.41 47.63 45.65 43.72 41.15 39.34 37.60 30.49 29.38 28.42
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49.82 51.03 52.32 54.22 55.69 57.21 52.23 53.13 54.51 55.61 56.80
58.56 59.92 61.34;
enddata
min=@sum(link:x*distance);
@for(orientations(i):@for(people(j):@sum(locations(k):x(i,j,k))=1;);)
;
@for(locations(k):@sum(link(i,j,k):x(i,j,k))=1;);
@for(orientations(i):@for(people(j)|j#lt#68:@sum(locations(m):distanc
e(i,j,m)*x(i,j,m))<=@sum(locations(n):distance(i,j+1,n)*x(i,j+1,n));)
;);
@for(link:@bin(x););
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