SJMMA 2022 A 题

校园游览

P校是一所优秀的高等学府，也是当地极具盛名的旅游景点。然而，纷至沓来的游人为学校的管理和校内工作带来了很大压力。P校正在考虑采取预约入校、引导人流等措施改善当前状况。

P校的简化地图，图中可见校内大致分为景观区域（红色建筑、大片水域与绿化）、教学科研区域、用餐设施和生活区域。景观区域可供游人自由参观驻足；教学科研区域的各式建筑往往吸引游人摄影留念，但禁止入内参观；生活区域主要为学生宿舍，无景观，也不希望游客进入。依照P校规定，游客只能由A1、A2、A3门进入校园，而可以从任意校门离开；但由于B1校门为一著名景观，较多游客会由此出校此外。

通过管理措施，P校期望在任一时刻，校内游客的总人数不要过多，景观区域和教学区域单位面积人数也不要过多。

任务一：P校采用传统的排队方式让游人进入校园。请根据以下几种情况分别对游人行为建立模型，并求出对于不同的总人数或单位面积人数限制（注：允许人数限制变动是合理的，例如工作日、节假日、考试日对游客数量的限制显然未必相同），A1、A2、A3每分钟能允许多少游人进入校园？

（1）所有游人都将从B1门离开，且只会进入景观区域和教学科研区域（注：请保证每个门的路线能走通）。请在以下几种假设下，**分别**考虑此问题：

①游客均只参观S1景点；

②游客均只参观S1景点，但在中午时段，部分游人会在半途中尝试前往用餐区域就餐。假定他们不会途径生活区域，而只会在由其他类型区域能到达的用餐区域就餐。

③假定在同一条道路上（或同一个景点处），各个游客花费的时间相同。

（2）游人的离开位置与游览路径均不确定，其余条件与（1）③相同。

任务二：P校正在尝试一些措施对游客引导和入校管理。

（1）游客疏导。在各个生活区域与相邻区域连接处设立管理人员，引导来到此处的游客他们原路返回。其余条件与1（2）一致。这一设置会对各个门每分钟允许入校的人数有影响吗？如果有，可能有什么影响？

（2）入校方式。现P校决定试点网上预约入校，预约后无需排队可直接由三个入口校门进入校园。假设预约后，开放参观时的任意时间均可入校。假设每个门单位时间允许进入的未预约人数减少5%，则单日可放出多少网上预约名额？除了这个假设之外，你是否有更好的预约调度方式？

任务三：请为P校校长写一封非技术性报告，谈谈你的模型将如何有助于对校园游客的管理。

提示：

1景观区域内不仅有校外游客，还有校内教师与学生参观。他们的行为可能会对你的模型结果产生影响。你可以将这一因素纳入你模型，或简要分析这一因素可能如何影响你的结果。

2在必要时，对于游客的行为，你可以在合理范围内做一些个性化的假设；但是请不要简单地用一种精确的固定游览“路线”规范所有游客的行为。将游客分类可能会对你有所帮助。

注：如果你假定了游客在一个区域的活动，不要忘记在区域内部的可能的随机性。

3在具体问题中，如果你认为这有助于你的建模过程或对结果的讨论，你也可以为少数关键变量代入合理取值。

注意：此条仅限于少数重要变量，请勿滥用!

提交 你的团队所提交的报告应包含 1 页“总结摘要”，其正文不可超过 20 页（总页数限于 21 页）。附录和参考文献应置于正文之后，不计入 21 页之限。

P校简图

生活
用餐
景观
教育科研
水域
绿化
≠A1 B1 校门

道路
自行车道
步道

校园区域

S10
S8
B1 ≠
S7
S9
A5 ≠
≠ A6
≠ A1
D1
D2
S6
D9
S5
S1
S2
D3
D8
S3
D4
D5
D6
D7
S4
A4 ≠
≠ A2
A3 ≠

数据来自 openstreetmap.org

SJMMA2022 Problem A

Campus Tours

As a prestigious institution, P University is also a popular attraction for visitors. However, the overwhelming flux of visitors has exerted a considerable strain on the management and operation of the institution. Consequently, P University is now considering the installment of a visitor appointment system and/or pedestrian flow guidance to improve current conditions.

Figure 1 is a simplified map of the campus, which can be categorized as scenic areas, educational/research areas, dining facilities, and living quarters. Visitors are allowed to freely visit the scenic areas and the exterior parts of educational/research areas but are barred from entering the educational buildings and living quarters. Visitors are only allowed to enter via gates A1, A2, or A3 but can exit at any gate, among which gate B1 is a popular attraction whereby many visitors exit.

By employing the aforementioned strategies, P University intends to limit the total number of visitors on campus, and the crowdedness of visitors in scenic and educational/research areas.

Task 1. Visitors enter the campus via the conventional queuing system. To meet the visitor number caps (which should be allowed to vary, as these limits are probably different on weekdays and holidays, or when important examinations are taking place), please model the behavior of visitors under the following scenarios and determine the tolerable number of admissions per minute at each gate.

(1) All visitors only pass through scenic and educational/research areas and leave at gate B1. Please consider the problem under the following assumptions respectively:

① Visitors only visit attraction S1;

② Visitors only visit attraction S1, but some of them would have lunch in dining areas at noon. Assume that their passage to the dining areas does not trespass living quarters.

③ All visitors spend the same amount of time on the same path/attraction.

(2) Based on (1) ③, remove the assumptions on the visit path and exit locations.

Task 2. Consider the visitor management strategies:

(1) Visitor guidance: Under scenario 1(2), personnels are deployed along the perimeter of living quarters to send back visitors wandering into these areas. If and how could this strategy impact the tolerable number of admissions at each gate?

(2) Entrance to campus. P University intends to install a piloting online visitor appointment system whereby visitors can enter at any of the three entrance gates without queueing upon entrance. Assume that visitors can enter at any time when the campus is open. If the tolerable number of admissions to visitors without appointment at each gate is reduced by Reduce%, how many appointments can be arranged each day? Are there any superior alternatives to this assumption?

Task 3. Write a non-technical report to the president of P University to explain how your model will provide insights on visitor management on campus.

Notes:

1. Students and faculty are also present on campus in addition to tourists, which can impact your models. You may incorporate this factor into your models; alternatively, you may briefly discuss how this might impact your results.
2. Where necessary, make plausible assumptions on visitor behavior, but in any case, please do not designate the same visit path for all visitors.
3. Certain key variables can be assigned reasonable values in case this should help with your modeling or discussion. However, this should not be overused.

Submission Your solution paper should include a 1-page Summary Sheet. The body cannot exceed 20 pages for a maximum of 21 pages with the Summary Sheet inclusive. The appendices and references should appear at the end of the paper and do not count towards the 21 pages limit.

P校简图

Living
Dining
Scenic
Educational/Research
Waters
Greenings
≠ A1 B1 Gate

Roadway
Bikeway
Footpath

Campus

S10
S8
B1 ≠
S7
S9
A5 ≠
≠ A6
≠ A1
D1
D2
S5
S6
D9
S1
S2
≠ A2
D3
D8
S3
D4
D5
D6
D7
S4
A4 ≠
A3 ≠

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