Maximizing capacity under social distancing policies when seating arrangement is fixed

A Case Study of Clough Commons 152

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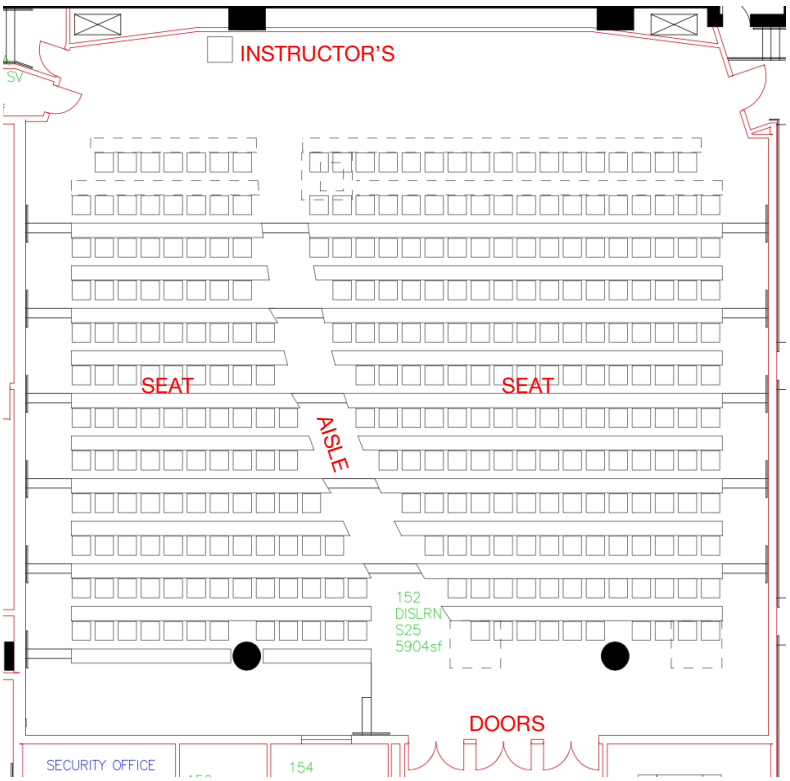
Preface

To support campus restart in the coming semester and ensure students' safety regarding the COVID-19 situation, we build an optimization model for fixed-seats classrooms to figure out the possibly maximum capacity with the social distancing requirement suggested by CDC [1]. Here is an example of applying our model to one representative classroom, Clough 152, at Georgia Tech. We believe our model can be useful to any classroom with fixed tables and chairs.

Section 1: Introduction of Clough 152

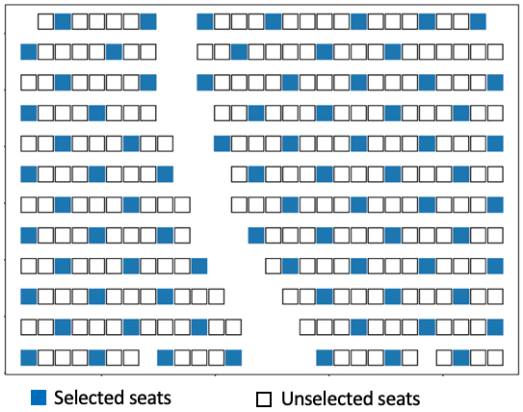
Clough 152 is an originally 300-seat classroom at Georgia Tech - Atlanta Campus. This classroom is equipped with fixed continuous tables with loose chairs. A layout of Clough 152 is in Fig 1. We assumed that chairs are fixed in Clough 152 to testify our optimization model with the purpose of finding the maximum number of seats that can be used while satisfying social distance requirements and other possible prevention constraints.

Fig 1. The indoor layout of Clough 152

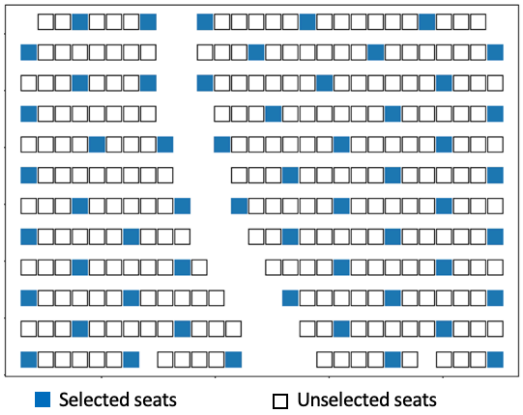


Section 2: Maximum capacity considering only social distances

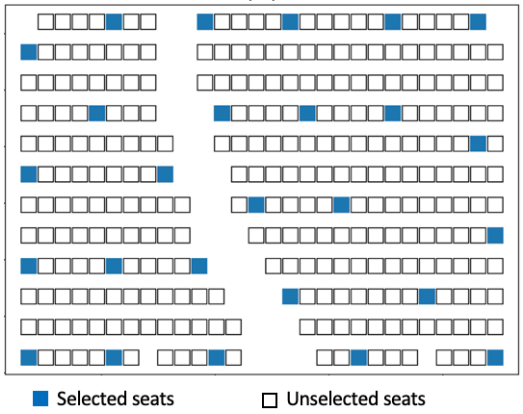
We first consider choosing as many seats as possible while keeping d_0 feet social distance between selected seats. An integer programming model is formulated to find the optimal solution. Fig 2 shows selection of seats when d_0 is set as 6, 8 and 12 feet. IP model formulation can be found in the Appendix.



(a)



(b)



(c)

Fig 2. Seating Arrangement in Clough 152 under social distance: (a) 6'; (b) 8'; (c) 12'

When d_0 is 6, 8 and 12 feet, the maximum number of selected seats are 78, 55, and 26 respectively. The utilization of original 300 seats in the classroom drops dramatically as social distancing increases. Maximal percentages of seats that can be selected under different social distance settings are obtained by solving the IP model with different d_0 and are shown in Fig 3.

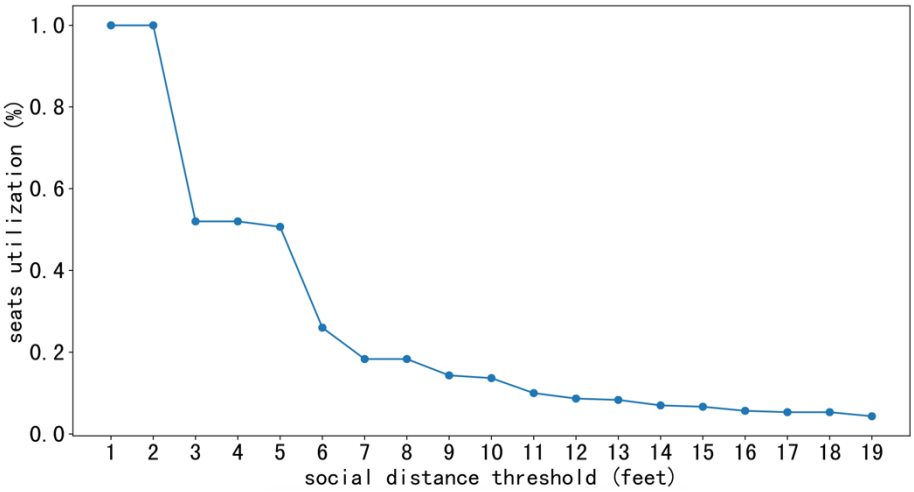


Fig 3. Seats utilization in Clough 152 vs. the social distance

Section 3: Maximum capacity considering preventions

We also consider preventions for the seating arrangement so that stakeholders can realize some of their realistic considerations when making decisions.

Preventions included in the optimization model are:

- No selected seat near the instructor: Since the instructor needs to talk for a long period of time during lectures, sitting near the instructor can be close contacts and therefore has high risks [2]
- No selected seat near the aisles and doors: Aisles and doors usually are high-traffic areas in classrooms where the probability of COVID-19 transmission can be higher

For the prevention that no seat near the instructor, we provide two ways to realize it:

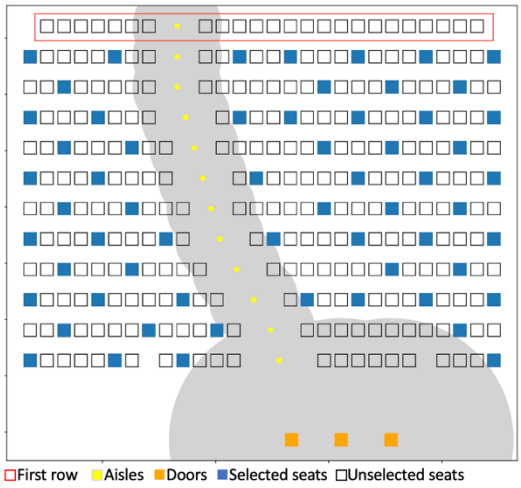
- Input the location of the instructor as a single point and a safety distance from this location. Any seat within this safety distance will not be considered
- Incorporate movements of the instructor. We assume the instructor can easily get contact with the first row. Therefore, any seat in the first row will be eliminated

For aisles and doors, the model requires for locations of them and also the safety distances. The location of a door is a single point while the location of an aisle should be a series of points in the middle of the aisle to capture its "shape" (see yellow dots in Fig 4).

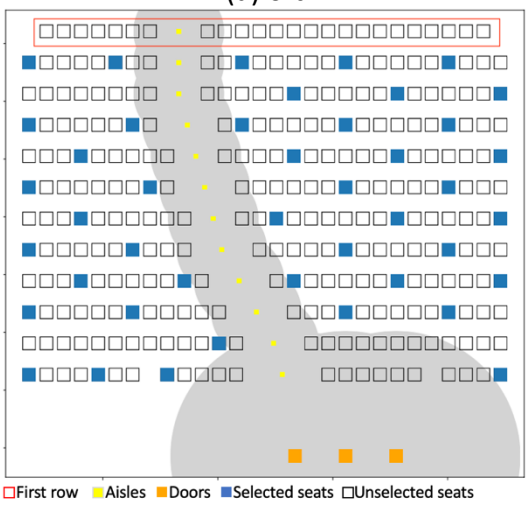
Several results from applying our model on Clough 152 with preventions that no selected seat in the first row or near the aisles or doors but with different social distances are shown by Fig 4. Safety distances we use can be seen in Table 1.

Table 1. Safety distances for Clough 152

Preventions	Safety distances	Description
The first row	NA	No selected seat in the first row
Aisles	6.75’	This safety distance makes sure that any seat exactly near the aisle will not be considered
Doors	18’	Demo data. Users can input any data to decide how conservative they are about seats near the doors



(a) 6ft



(b) 8ft

(c) 12ft

Fig 4. Seating Arrangement in Clough 152 with preventions and social distance: (a) 6'; (b) 8'; (c) 12' (maximum capacity is 60, 43, 22 seats for (a), (b), (c) respectively)

Appendix

Integer programming model formulation:

- Decision variables: $x_s = \begin{cases} 1, & \text{if seat } s \text{ is selected} \\ 0, & \text{otherwise} \end{cases}$, $s \in S$ where S is the set of candidate seats.
- Objective function: $\max \sum_{s \in S} x_s$
- Constraints: for two different seats $s_1, s_2 \in S$, if the distance between them is strictly smaller than social distancing threshold (d_0), then $x_{s_1} + x_{s_2} \leq 1$.

References

[1] CDC, *Coronavirus Disease 2019 (COVID-19)*, 2019. Available from: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html, accessed 2020 May 18.

[2] CDC, *Considerations for Institutes of Higher Education*, 2020. Available from: https://www.cdc.gov/coronavirus/2019-ncov/community/colleges-universities/considerations.html, accessed May 24, 2020.