Next: preliminary results from first floor CAD

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Key points

- Based on the provided CAD file (titled 'Front Building 1st.dwg', received 29/06/2020), we achieved a maximum seat occupancy, with a 2m social distancing measure, of approximately 45% without shielding, a significant improvement on the benchmark supplied at 28%.
- We have developed a new web-based application which is specific to the Next first floor layout, available here.
- A key assumption is that we are optimising only the number of available seats. This creates regions where people must walk through other people's 'safety bubble' to access other facilities in the building.

What we could do next

- Given the potential shield locations in the CAD file, we could simulate scenarios using shielding.
- We can model other floors.
- We can optimise our model to potentially return a greater seat occupancy.
- We could refine our model to add in other factors, for example reducing exposure on walkways.

Costings for further work

During this work, we established a new app which, currently, contains only the layout of the old office first floor. We reformatted the information from the CAD file so that it could interface with our app, and then ran our algorithm to determine a suitable seating plan. Further, we conducted a mathematical investigation of the problem to determine whether a true optimum is easily available, and then developed methods that could potentially improve on the first result found. In total, this work took approximately 1 month to complete, and for a similar level of work to be undertaken in the future we would request remuneration of £3000. However, the exact cost of any future work would be subject to the quantity of work undertaken, and the level of complexity of the required work.

Methods and results

Using the CAD file provided we reformatted the information to be compatible with our app. Upon selecting a fixed desk, the algorithm sweeps through all other seats and removes any desk that is within the social distance measure provided, repeating this process until all available desk spaces have been checked. In order to find an optimal solution, we simulated the desk selection randomly 5000

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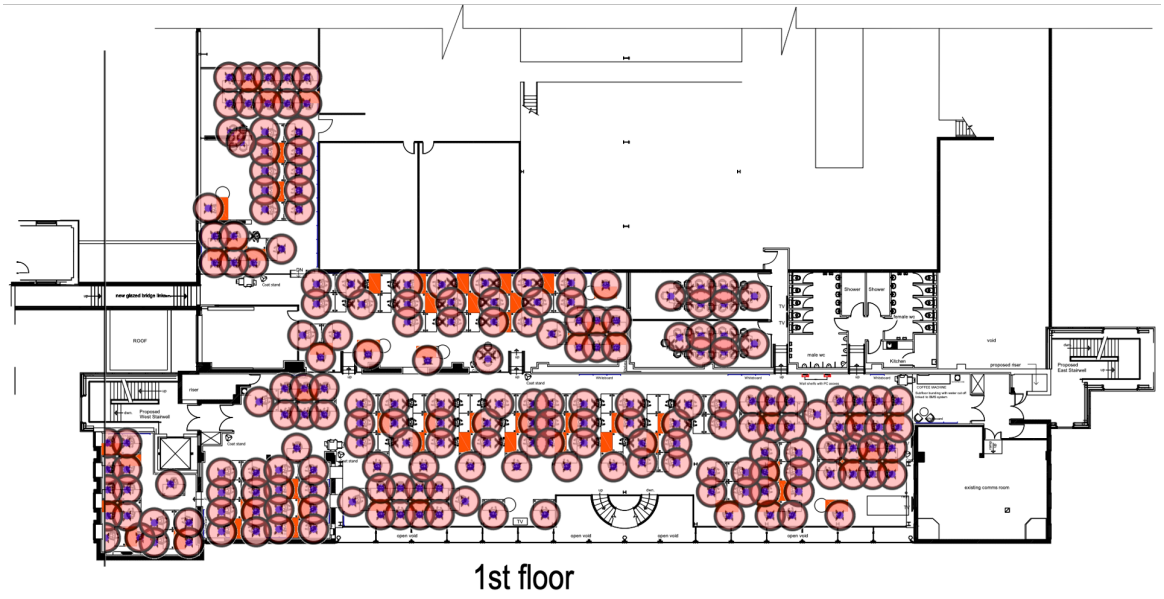

(a) A sample layout for a social distancing measure of 1 metres, which uses 201 seats.

(b) A sample layout for a social distancing measure of 2 metres, which uses 105 seats.

Figure 1: A proposed office layout given by the app for 1 and 2 metre social distancing. Seat locations are marked with crosses, available seats are marked with dots and the 'region of safety' is denoted by a circle around the available seats. Overlapping circles imply that certain regions are exposed to contamination from multiple sources, but no available seats are located in these regions.

times , selecting the order of fixed seats that yielded the greatest capacity. The results of the optimal desk selection algorithm are displayed in Figure 1 and in Table 1. We have run simulations including and excluding the conference room.

As demonstrated in Table 1, we can very quickly achieve significantly higher occupancy rates in the office whilst maintaining social distancing measures. Given more time, we can search to see if our results can be further optimised and our model further improved, as well as develop methods for user specification of shield locations (see first app).

	Maximum capacity at 2m social distancing (%)
Next CAD file benchmark	27.9
Cardiff App with conference rooms	43.0
Cardiff App without conference rooms	45.2

Table 1: Comparison of the performance of the Cardiff seat finding app against the benchmark provided in the supplied CAD file.

Prospective developments for improving optimality

Our app always provides seating arrangements that maintains social distancing measures and provides locally optimal solutions which are already better than the 28% benchmark provided. Returning the absolute optimum arrangement is a lot more difficult because the problem is what is known as 'NP-hard'. Simply put, the only way to guarantee you have the most possible seats used is to try every possible order of seat checking, and pick the one which has the most seats used. Actually trying out every seat ordering would take a very long time; there are more ways to order 253 seats than there are particles in the universe.

To improve our model, we could develop techniques to check our solutions and continuously improve upon them where possible. This would improve the likelihood we will find the best possible seating arrangement. For example, our current results are optimal up to $5,000$ simulations, however, this can extended with more computational power and further theoretical applications.