Optimizing classroom assignments to minimize instructors travel distance

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ABSTRACT

Classroom assignment is a critical academic planning step in higher education institutions. In this work, we studied the Classroom Assignment Problem using data from the Boston University Fall 2023 Semester. We implemented a swap heuristic to update the current university provided by the Office of Registrar at Boston University. We used it as a post-optimization strategy to minimize the instructors' total traveled distance. The heuristics implementation improved up to 9% in the achieved computational results compared to the initial classroom assignment.

CCS CONCEPTS

• **Theory of computation → Scheduling algorithms**.

KEYWORDS

Classroom allocation problem, heutistics, undergraduate research

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1 RESEARCH CONTEXT AND PROBLEM

In many universities and colleges worldwide, instructors must face a common issue every upcoming semester: determining when, where, and who will occupy a classroom to hold their lectures. Currently, at Boston University, lecture locations between course sections can be far away from each other, making travel time and distance too long and inconvenient for instructors. The way that classes are scheduled can be described as either an interval or non-interval problem, with consideration for monotonic preferences. Thus making the complexity of our problem in this specific context anywhere from polynomial time solvable to *NP-complete*. [1] The focus of this project is to optimize classroom assignments considering the total traveled distance by the instructors.

2 METHODOLOGY

We begin with data analysis by utilizing a spreadsheet containing the Fall 2023 class schedule for Boston University. We are particularly interested in each class section's Department, Buildings, and Room capacities. Based on the existing classroom schedule we designed an Object-oriented model, as can be seen in Figure 1, that will be used during the optimization process. We search for the locations of each as coordinates, with which we develop a helper program that will compute distances between buildings. The total sum of the distance traveled by all instructors from the schedule defines the schedule's upper bound.

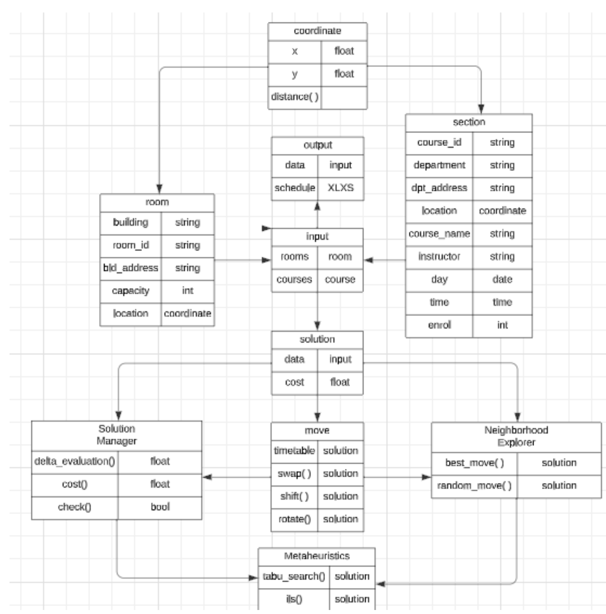

Figure 1: Object oriented model of the classroom assignment problem

Taking the current schedule and total distance traveled by instructors, we make adjustments to the schedule such that the new schedule results in minimized travel time among all instructors in

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all departments. These adjustments will be based on valid swaps of classes and if it decreases the total distance cost. A swap is considered valid if and only certain constraints hold, such as the start and end times of both of these classrooms are the same. We also have to check if the enrollment number of both classes fits within the limit of the designated rooms we want to swap. We know we can make the swap once we have gone through all these conditions. Finally, we must also check if performing this swap would make our total travel distance smaller.

3 RESULTS

Figure 2 shows the total traveled distance before and after the algorithm by each department in the College of Arts and Sciences. Our proposed algorithm benefits the instructors from the departments with the highest total traveled distances.

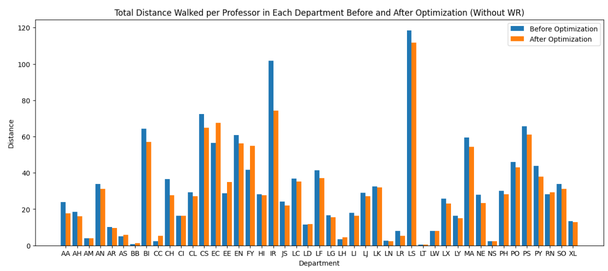

Figure 2: Total distance before and after algorithm by department

Figure 3 shows the total travel distance distribution. On average, we noticed that the instructors walked 2.28km per week, and at least half of the instructors walked at least 1.28 km per week. After using our algorithm, we obtained a new schedule in which the instructors would walk 2.09km on average, and at least half would walk at least 1.16km.

Figure 4 shows the algorithm's progress over a single execution. Starting from an initial course schedule, we tracked the total traveled distance after each swap. As can be seen, the total cost continuously decreases, revealing the effectiveness of this algorithm in improving the scheduling by assigning instructors to closer teaching facilities.

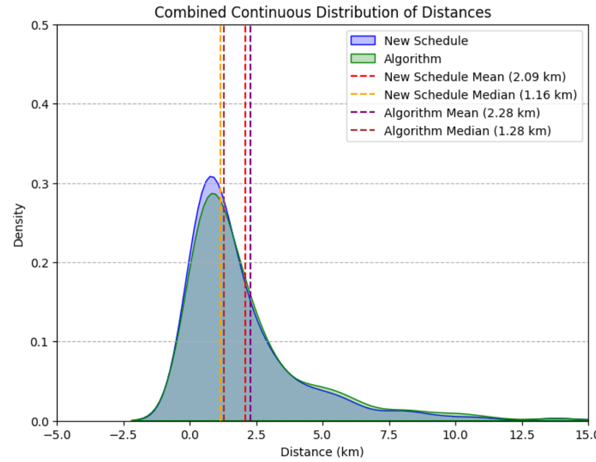

Figure 3: Overlayed distributions with means and medians

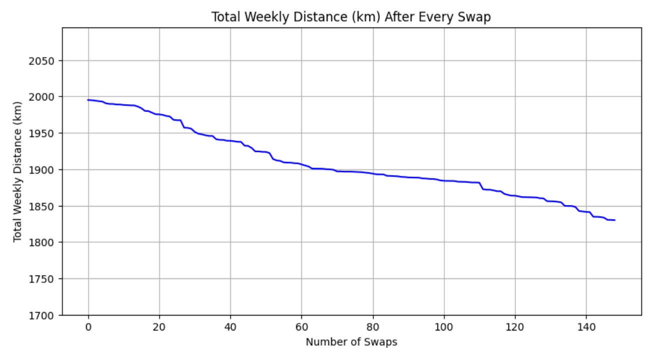

Figure 4: Total distance after every swap

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[1] Michael W. Carter and Craig A. Tovey. 1992. When is the classroom assignment problem hard? *Operations Research*, 40, S28–S39. Retrieved Oct. 18, 2023 from http://www.jstor.org/stable/3840833.

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