Schedule Summer Math Courses

University of Washington, Math Department
Yanmeng(Anny) Kong, Linni Cai

UNIVERSITY of WASHINGTON

DEPARTMENT OF MATHEMATICS

Problem Description

- Community partner:

  Sarah Garner, director of the Math Department Advising office

- Issue:

  The number of sections offered for math courses is not appropriate sometimes

- Cause:

  Students' tuition during the summer quarter goes mostly toward the salary of the summer quarter instructors

Problem Description - Example

Math 120

Year	Percent. Enrollment sec 1	Percent. Enrollment sec 2	Percent. Enrollment sec 3
2008	57.14(1050✓)	71.43(940✓)	77.14(1200✓)
2009	72.00(1050✓)	88.00(940✗)	104.00(1200✗)
2010	60.00(1200✓)	74.29(1050✓)	
2011	85.71(1050✗)	97.14(1200✗)	
2012	42.86(1050✗)	74.29(1200✓)	80.00(940✓)
2013	62.86(1050✓)	63.33(1200✓)	
2014	28.57(1050✗)	74.29(1200✓)	
2015	91.43(1200✗)		
2016	85.71(1200✗)		
2017	88.57(1200✗)		
2018	100.00(1200✗)		

- 100% enrollment in 2018 is not appropriate

Goal

1.1 Goal:

For this project, our goal is to *find appropriate schedules of sections for the following 9 non-major math courses,*

$$MATH\ 111/120/124/125/126/307/308/309/324,$$

such that each section has $57\%^1 - 80\%^2$ *student enrollment for at least* $95\%^3$ *of the time based on historical data.*

As requested, we would like to find appropriate schedules for the 2019 math summer courses, including the number of sections and time slots of sections.

Impacts

Afterwards, we will be able to answer the following questions for Mrs. Garner:

1. What's the recommended # sections and time slots for 9 non-major math courses?
2. If we want to open/close a new section, which section would we recommend to open/close first?
3. If we want to open/close a new course, which course would we recommend to open/close first?

Mathematical Model

3 Mathematical Model

With the 2008 – 2018 summer course end-of-quarter schedules provided by Mrs. Garner, we analyzed the raw data with some manipulations in Python and some visualizations in R.

To solve three questions mentioned in section 1.2, we have two stages:

1. Use linear programming to get the appropriate number of sections for each course at year 2019;

2. Use the Poisson simulation to find the specific time slot we want to select for each course at year 2019.

Stage I - Linear Programming

8.1.3 Objective function:

- To maximize the total number of sections:

$$max \sum_i S_{i,2019} \tag{1}$$

where

$S_{i,2019}$ = Predicted total # sections for course i in year 2019.

Stage I - Solving with Python

Find appropriate # sections for **previous years.**

2. **Compute linear programming I**

By applying constraints, we calculated the appropriate number of sections for each course for each previous year.

```
Let p be the enrollment percentage.
Let n be the appropriate section numbers.
Let n' be the previous section numbers.
For each course in each year,
    - If p >= 80 and p < 100, n should be 1/2 more.
    - If p >= 29 and p < 57, n should be 1/2 fewer.
    - If p > 100 or there is only one section with p >= 80 and p < 100,
      n should be one more.
    - If p < 29, n should be one fewer.
Finally, n should differ from n' for at most 1.
```

Stage I - Solving with Python

Find # sections for each course in **2019** using weighted average of previous years

3. Compute linear programming II

By adding weights and round down for the final result, the following algorithm presents the final # sections for each course in 2019.

```
With higher weights for the most recent 5 years and lower weights for
the least recent years, such that
    weight = [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6])
and all weights sum to 1.

Let n = appro.# sections with weights in 2019.
Then, n is a weighted average of all previous appropriate # section (from the last step).
```

Results - Stage

4.1 Stage I

By running the Python algorithm, we have the resulting recommended # sections as below.

Course	# sections
111	1
120	2
124	3
125	4
126	6
307	6
308	6
309	3
324	4

Table 1: The number of sections for each course in 2019

In our interpretation, for course Math 111, we recommend scheduling 1 section for 2019 summer; for course Math 120, we recommend scheduling 2 sections for 2019 summer; for course Math 124, etc.

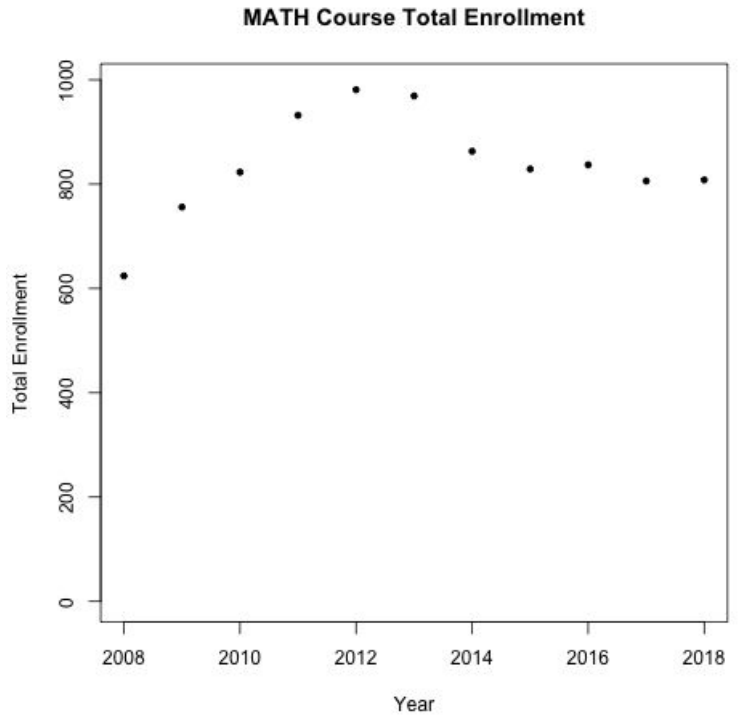
Poisson Distribution

3.2 Stage II

we calculate weighted average as following:

- With fixed i and k

$$\frac{\sum_j pe_{i,j,k} * S_{i,j} * w'_{j-2007}}{\sum_j S_{i,j} * w'_{j-2007}}$$

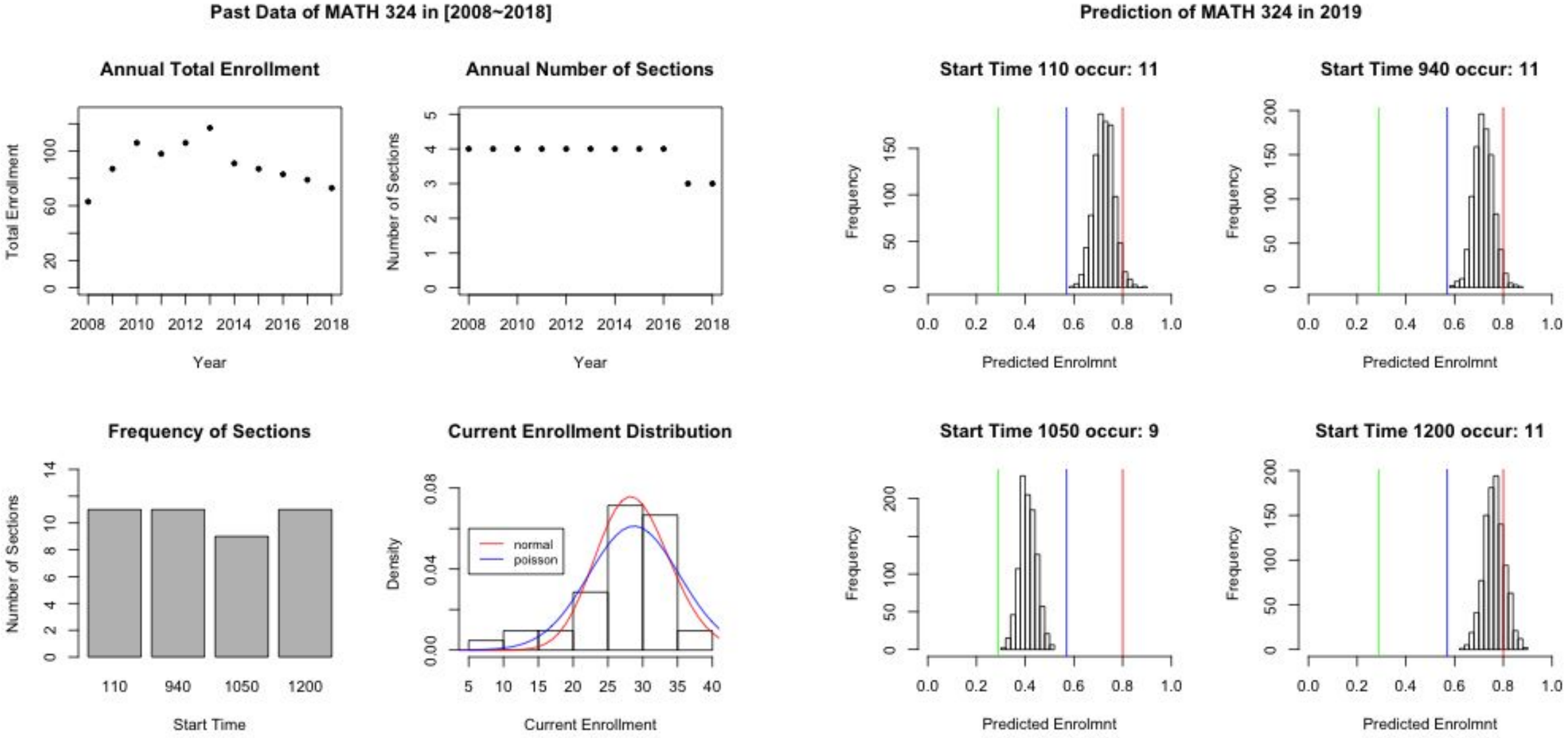


For example:

- We have calculated the weighted average for MATH 111 in time slot 10:50 am.

$$\frac{pe_{i,k,j=2008} * S_{i,j=2008} * w'_1 + pe_{i,k,j=2009} * S_{i,j=2009} * w'_2 + \ldots + pe_{i,k,j=2018} * S_{i,j=2018} * w'_{11}}{S_{i,j=2008} * w'_1 + S_{i,j=2009} * w'_2 + \ldots + S_{i,j=2018} * w'_{11}} \quad (13)$$

Priority Queue



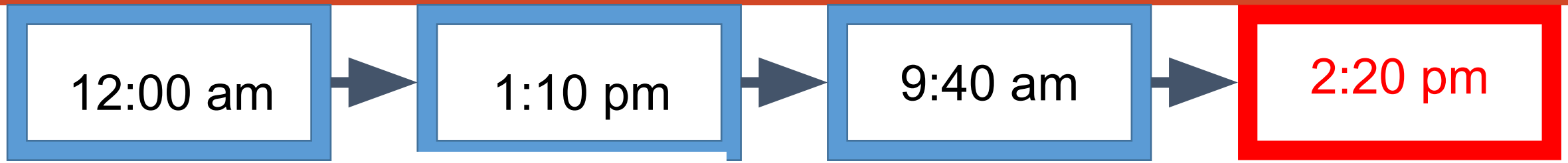
Priority Queue

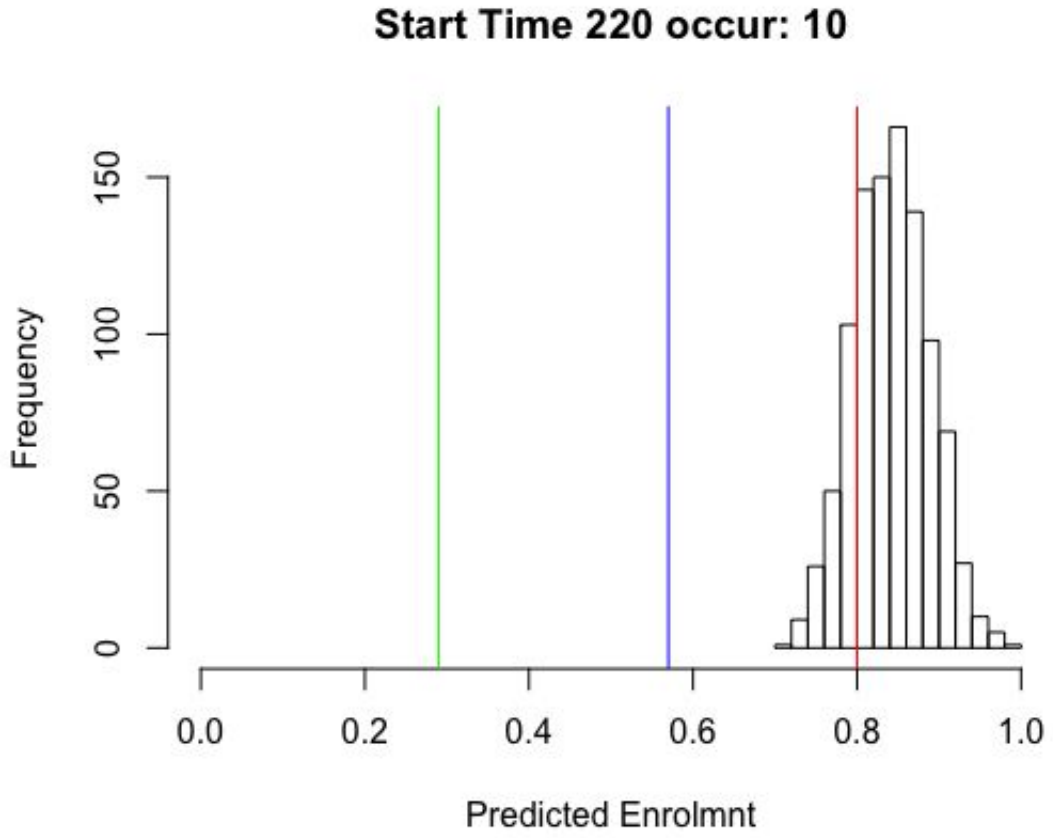
```
[1] 324
[1] "performance:"
  Section   > 0.8 LB   > 0.8 UB 0.57~0.8 LB 0.57~0.8 UB > 0.57 LB
5    1200 0.16580114 0.22116312   0.7532405   0.8656881  0.938973
1     110 0.02024087 0.04282687   0.9099099   1.0330158  0.938973
3     940 0.01617868 0.03690493   0.9147527   1.0381728  0.938973
  > 0.57 UB
5  1.063952
1  1.063952
3  1.063952

  Section Number
1     110      1
2     220      1
3     940      1
4    1050      0
5    1200      1
```

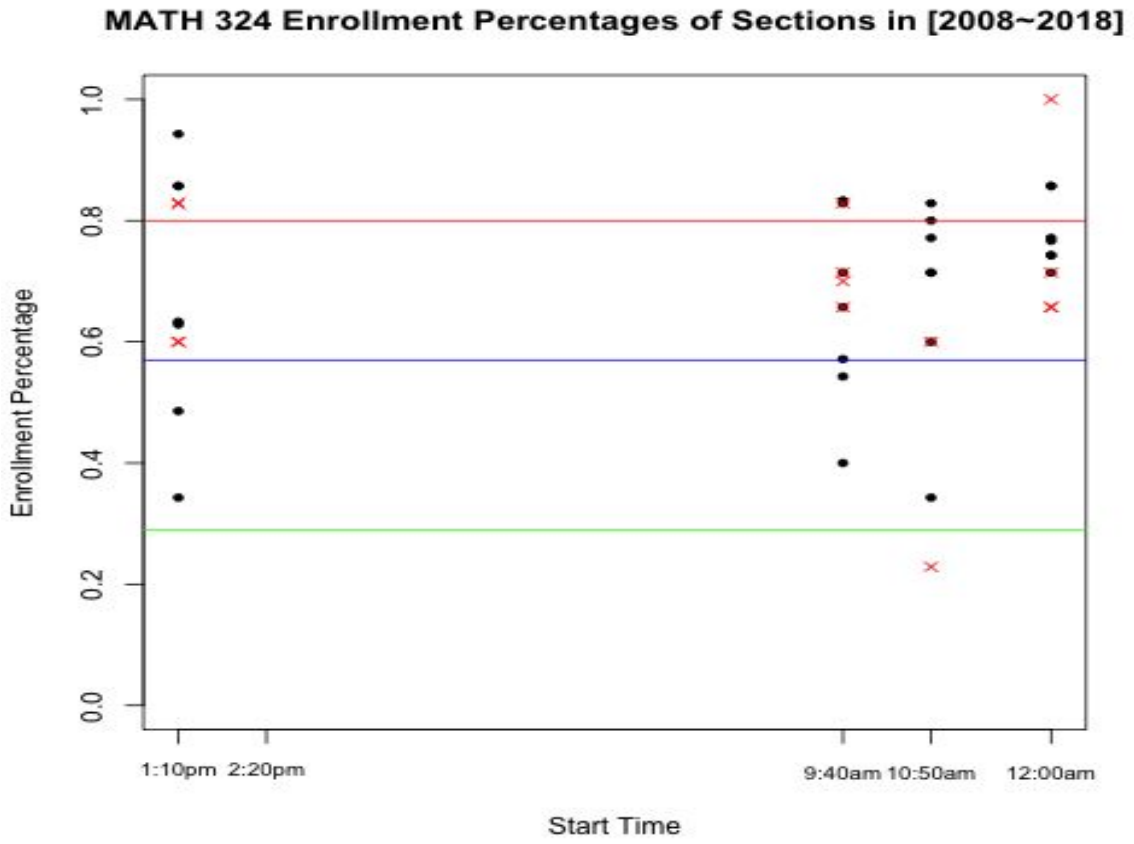
Confidence Interval at 95% For 3 regions: [LOWER+UPPER]

1. Upper region above upper bound of satisfied region 80%
2. Satisfied region between 57%~80%
3. Upper region above lower bound of satisfied region 57%

Priority Queue







Priority Queue

Time Slot	Number of Sections
9:40 am	1
10:50 am	0
12:00 am	1
1:10 pm	1
2:20 pm	1

Table 12: Section Schedule for Math 324 in 2019 (4 sections)

9. For MATH 324, we suggest to open four sections, one at 9:40 am, one at 12:00 am, one at 1:10 pm, one at 2:00 pm.

Priority Queue

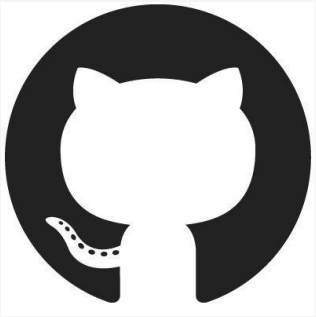
Time Slot	Number of Sections
9:40 am	1
10:50 am	0
12:00 am	1
1:10 pm	1
2:20 pm	1

Table 12: Section Schedule for Math 324 in 2019 (4 sections)

9. For MATH 324, we suggest to open four sections, one at 9:40 am, one at 12:00 am, one at 1:10 pm, one at 2:00 pm.

Thank you

Get more details of our project in Github



https://github.com/MathSummerProject