CS712/812 - Stochastic Modeling

Spring 2018

Programming Project: Modeling time-dependent parking lot occupancy

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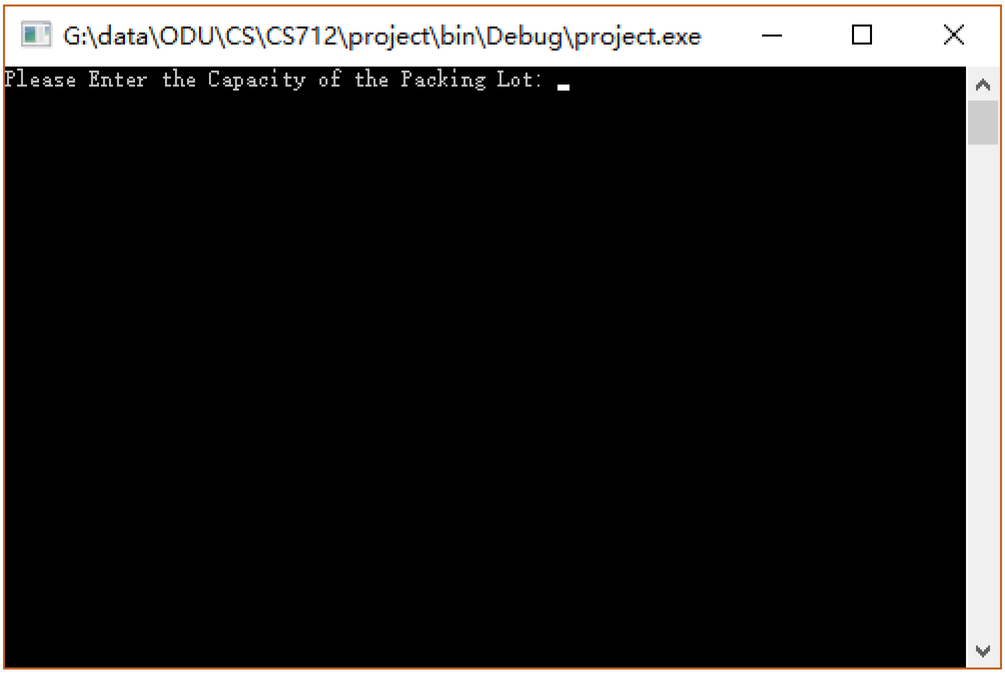
1. Model Selection

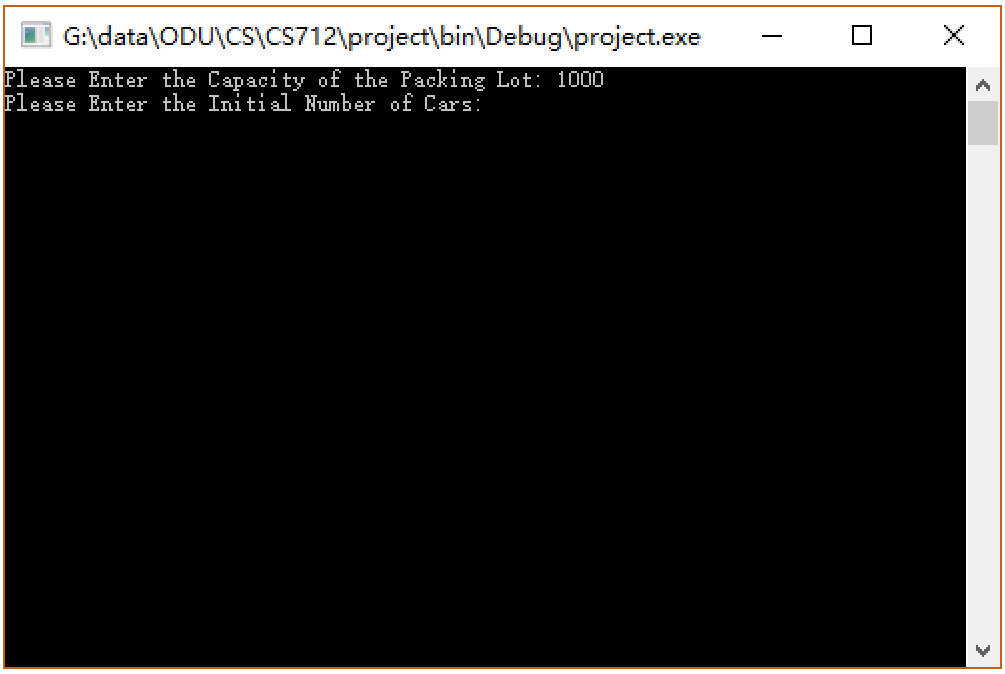
This problem can be modeled as a Birth and Death Process, so that $\alpha_k(t)$ is the birth rates and $\beta_k(t)$ is the death rates. So at every single time t, there is a probability $1 - e^{-\alpha_k(t)}$ that a car is coming and a probability $1 - e^{-\beta_k(t)}$ that a car is leaving. Then the number of cars in the parking lot will be updated with the time passes.

2. Execution

1) When you run the program, first you will be asked to input the capacity of the parking lot. Please enter an integer (e.g. 1000).



2) Once you enter the capacity of the parking lot, you will be asked to enter the initial number of cars. Please enter an integer (e.g. 500).



3) After you enter the initial number of cars, the program will start the 14-day simulation and the final result will be output in 2 files named “constantSimulation.txt” and “periodicSimulation.txt”.

3. Parameters

The result in this report was given by these parameters:

$$Total\ Simulation\ Time = 14\ days, \qquad \Delta t = 1\ second, \qquad N = 1000, \qquad n_0 = 500$$

1) Constant arrival rate and departure rate condition

$$\lambda = 18000/hr, \qquad \mu = 2/hr$$

2) Arrival and departure rates as periodic functions

$$\lambda(t) = (15000 + 14000 \sin\frac{\pi t}{12})/hr, \qquad \mu(t) = (3 + \sin\frac{\pi t}{12})/hr$$

4. Result

The simulation of 14 days generated 1,209,600 point-in-time, but Excel is not able to hold such many data. So in this part we just show the first 12 days’ result.

To evaluate the accuracy of the simulation, we compute these values:

$err = \sqrt{\frac{\sum_{t=1}^{n}(X(t)-E[X(t)])^2}{n}}$: It shows the average error of a single point-in-time

$perr = \sqrt{\frac{\sum_{t=1}^{n}(\frac{X(t)-E[X(t)]}{E[X(t)]})^2}{n}}$: It shows the average error percentage of a single point-in-time

In the constant arrival rate and departure rate condition, ***err*** is 8.93, ***perr*** is 1.01%, which means there are only less than 9 (about 1%) cars away from the prediction on average at any time. In the condition that arrival and departure rates are periodic functions, ***err*** is 12.27, ***perr*** is 2.07%, which means there are only about 12 (2%) cars away from the prediction on average at any time

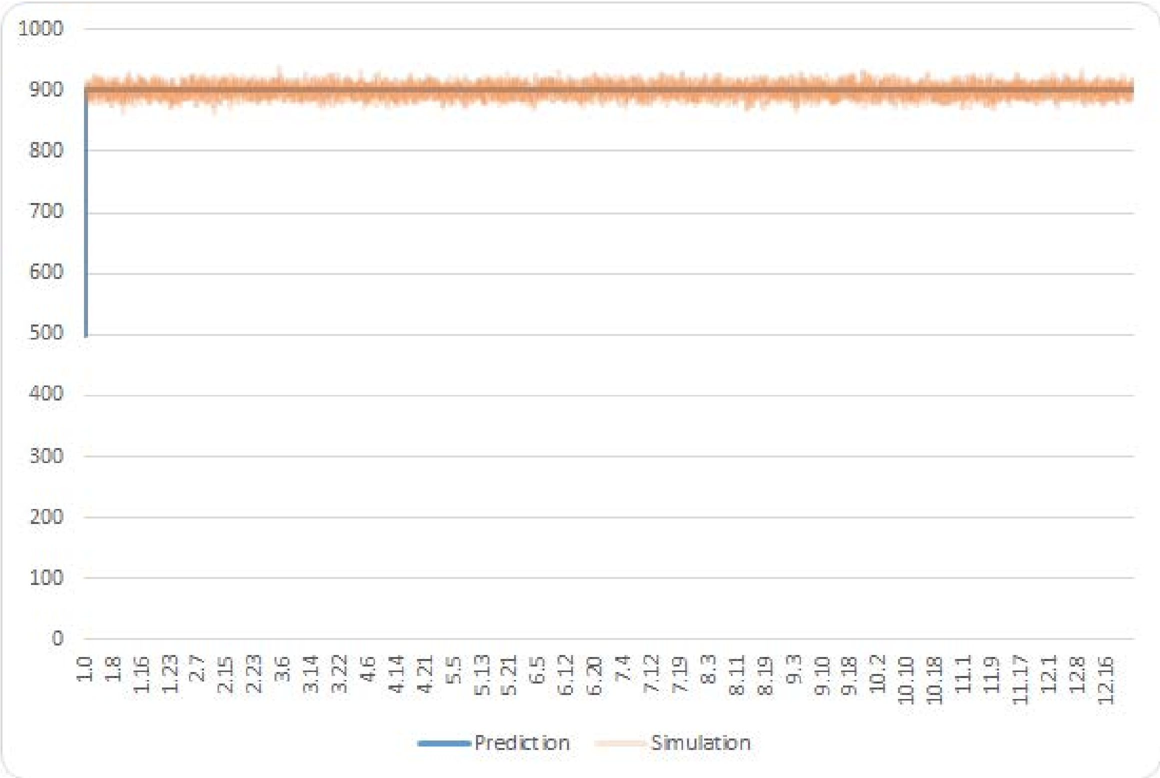


Figure 1: Constant Rate Prediction vs Simulation (12days)

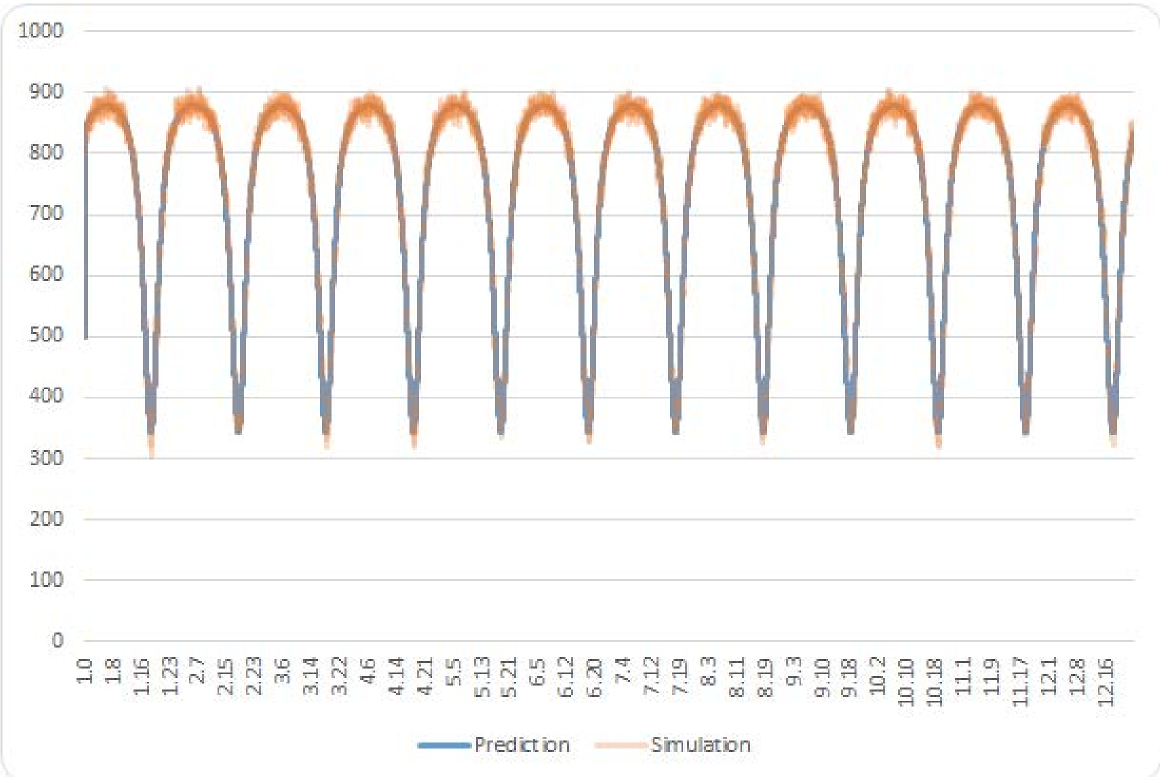


Figure 2: Periodic Rate Prediction vs Simulation (12 days)

Focused on the first day, both of the prediction and simulation in either condition grow extremely fast at the beginning and reach the high level in merely half an hour, which shows that the initial number of cars matters quite little.

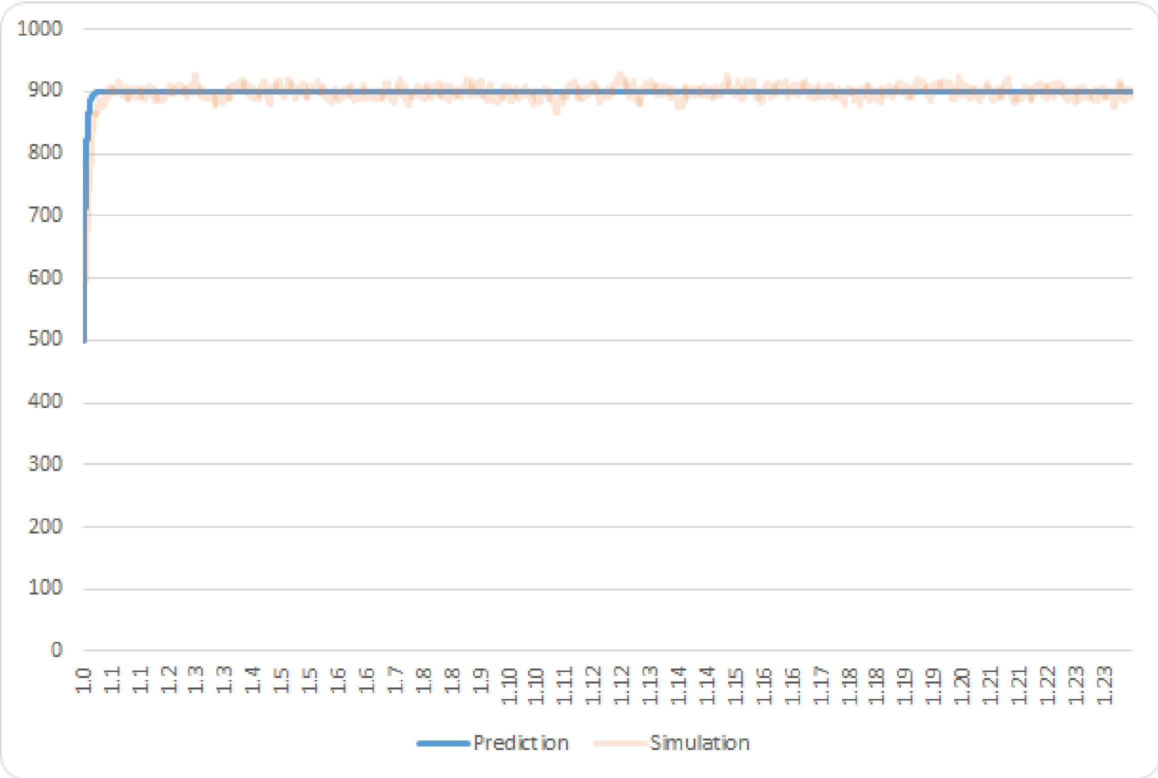


Figure 3: Constant Rate Prediction vs Simulation (1st day)

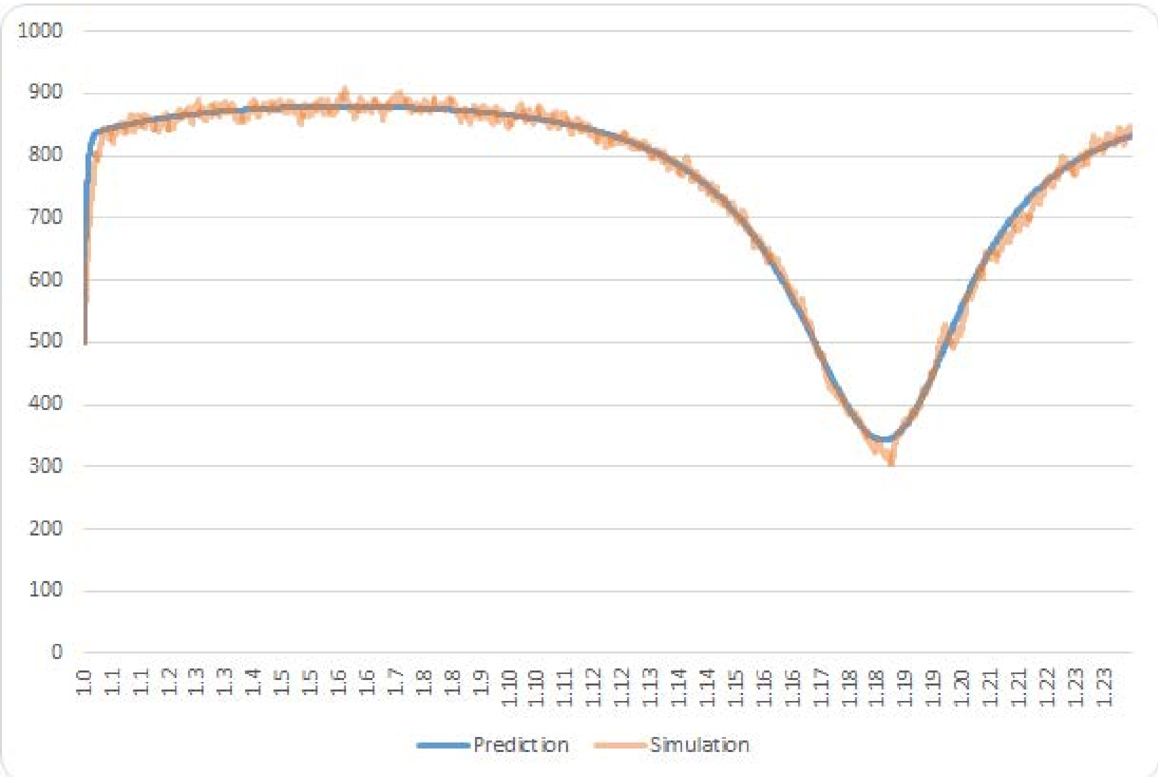


Figure 4: Periodic Rate Prediction vs Simulation (1st day)

5. File List

parkingLotSimulation.cpp: C++ source code of the simulation program

predict.R: R script for computing the predict values

constantSimulation.txt: Simulation result of constant arrival rate and departure rate

periodicSimulation.txt: Simulation result of arrival and departure rates as periodic functions

constantDay1.csv: First day's prediction values of constant arrival rate and departure rate

constantDay2.csv: Other day's prediction values of constant arrival rate and departure rate

periodicDay1.csv: First day's prediction values of arrival and departure rates as periodic functions

periodicDay2.csv: Other day's prediction values of arrival and departure rates as periodic functions

plot.xlsx: The spread sheet for plotting the simulation and prediction curves