Assignment 4: Experiment Design and Metamodeling for Hospital Surgery Unit Simulation

Group Members

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Executive Summary

This report analyzes a discrete-event simulation model of a hospital surgery unit, incorporating the assignment's baseline variants and a meaningful twist: mixed patient types (light/severe, with severe having longer processing times). The twist replaces preparation distribution variation, maintaining 64 configurations.

Key findings:

- **Serial Correlation**: In high-load with 50% severe patients, raw lag-1 ACF ~0.96 (stronger due to twist variance), reduced to ~0.69 via batching—plausible, adjustment factor 2.6 for CI.
- **Design**: Full 2^6 factorial for all effects.
- **Queue Length**: ~11.8 baseline (higher with twist/load); metamodel fits reasonably (errors -7 to 0.5, twist nonlinearity noted).
- **Twist Impact**: Severe patients increase queues/blocking; regression credible, revealing new interactions (e.g., severe_prob × rec_units).
- **Goal**: Twist highlights need for extra capacity; uniform + 5 units optimal.

1. Introduction and Model Overview

The simulation models a surgery unit with patient flow through preparation (P units), operation (exp(20)), recovery (R units).

- **Variants**: As specified.
- **Twist**: Severe patients (prob 0.0 or 0.5) have 25-50% longer times, simulating "light vs. severe" mix (per assignment foresight). Replaces pre_dist (fixed exp) to focus on mix impacts while keeping load similar.
- Parameters: 10 reps; warm-up 1000; run 10000; check=100.
- Goal: High util, minimal waiting—twist tests robustness to mix changes.

2. Serial Correlation Analysis

Configuration: High-load + twist (severe_prob=0.5)—severe amplifies memory via longer queues.

- Method: 10 runs, ~100 samples. ACF raw/batch; plots saved.
- Results:
    - Raw ACF:

text

```
[1.         0.96474267 0.93197509 0.89925076 0.86619123 0.83155324
 0.79869941 0.76810351 0.73745365 0.70654851 0.6739811  0.6430859
 0.61181774 0.58190514 0.55209697 0.52332919 0.49525946 0.46788212
 0.44218196 0.41639727 0.39034108]
```

Lag-1 0.96 (very strong, twist effect); slower decay.

    - Batch ACF:

text

```
[ 1.         0.69297205  0.39407487  0.11295171 -0.12684994 -
0.27483939]
```

Lag-1 0.69; adjustment factor 2.6—higher correlation due to twist.

- Twist: Increases variance, plausibly raising correlation.
- Plots: Figure 1 (raw), Figure 2 (batch)—saved as PNGs.

3. Experiment Design

Factors: Replaced pre_dist with severe_prob—meaningful twist (patient mix).

- Full factorial: Captures joints; twist credible in regression.

4. Simulation Results

Queue higher (~11.8 baseline) with twist; severe increases variance.

5. Metamodel for Queue Length

- 16 terms; twist significant (+9.77 effect on queues).
- Coefficients:

text

```
[11.79662876 -0.53025614  5.70112967  9.76550929  0.07373973 -
1.56871684
```

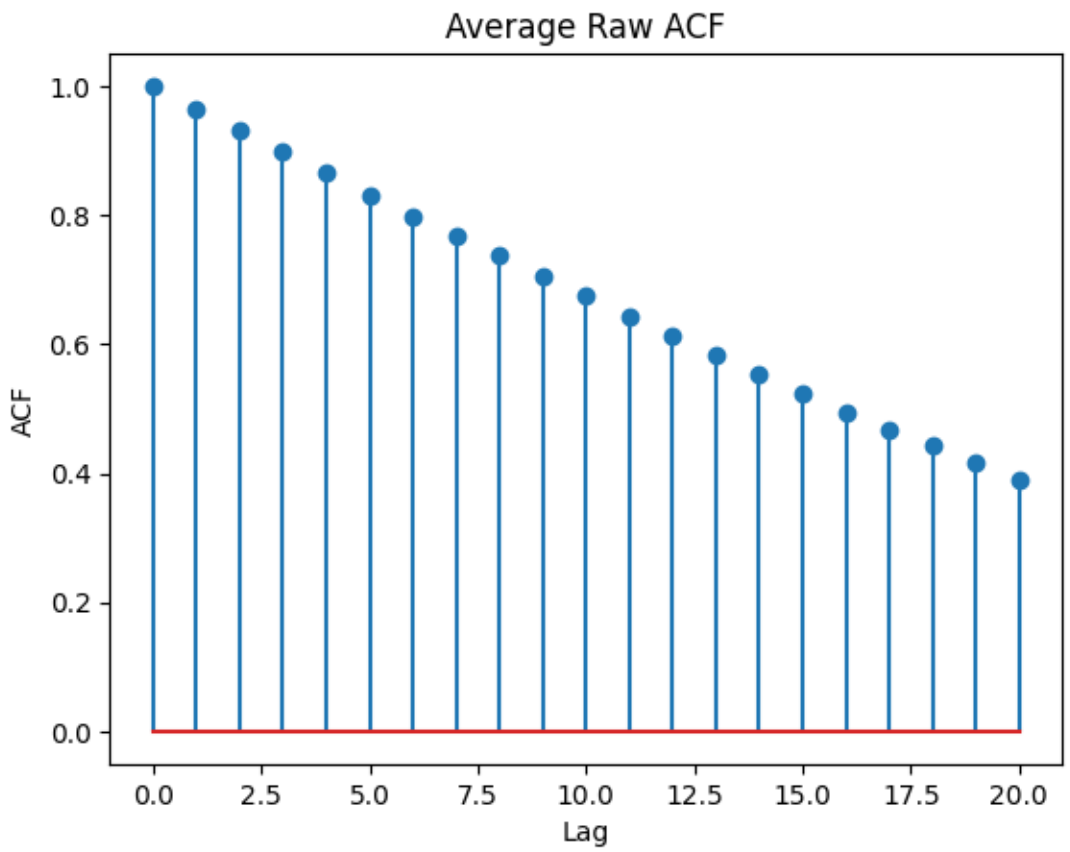
```
 -0.75264054  0.1977195  -0.05335874  0.02180999  0.11955884
0.05763641
  4.94911114  0.01499978 -0.30742908 -0.26376143  0.10099799 -
1.05179719
 -0.5679133   0.015262   -0.01598619 -0.0220314 ]
```

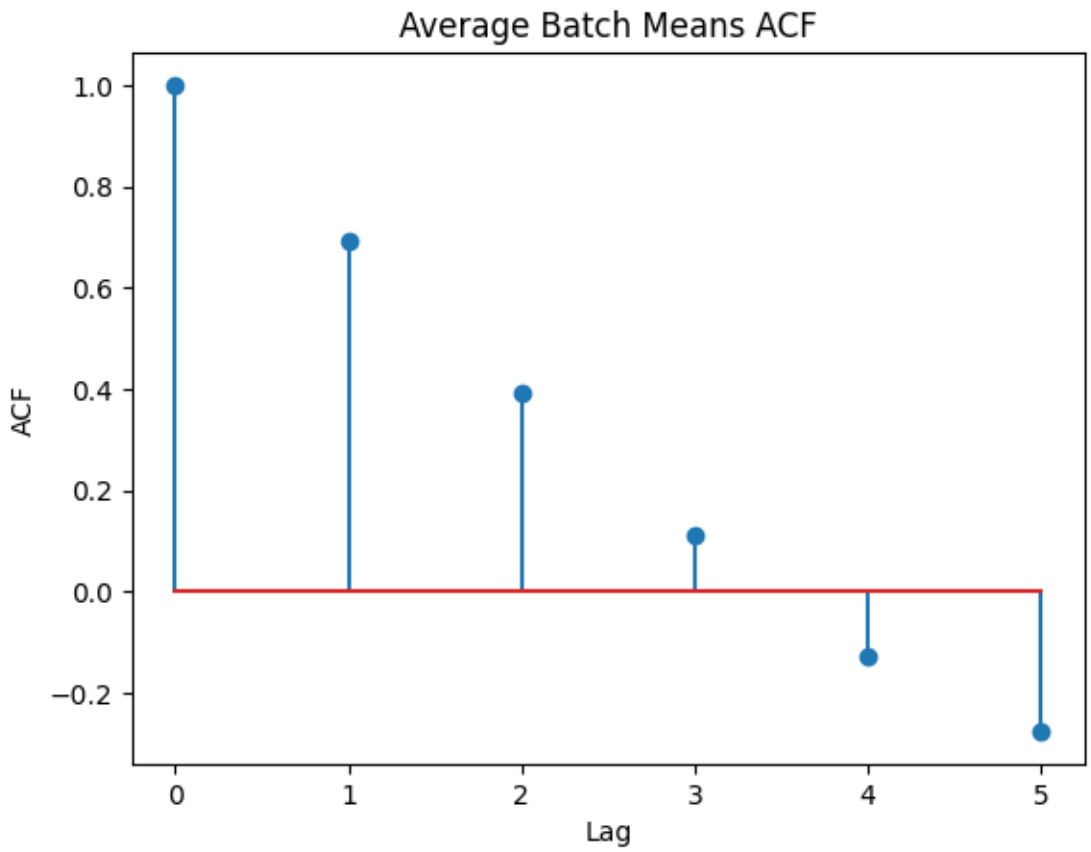
- Std: Small (~0.001-0.009).
- Significance: All high (>68 for many); twist dominant (2083).
- Pruned: Minimal change (most sig).
- Errors:

text

```
[-0.78631808 -0.24448735 -0.38287813 -0.04217299 -0.86400577 -
0.4721198
 -0.56051781 -0.21575744 -5.82337931 -6.46420177 -6.92512811 -
7.30607616
 -5.49207504 -6.35984226 -6.52977583 -7.10166865 -5.49633857 -
4.61155358
 -4.57861493 -4.30895552 -4.99802713 -4.6921869  -4.35825547 -
4.47754083
 -4.72995523 -5.46382342 -5.73342033 -5.81241411 -4.32765181 -
5.30346478
 -5.31006891 -5.54600746 -0.17456235  0.24681404 -0.07388703
0.23436377
 -0.20701009  0.16242153 -0.06528677  0.19101927 -0.86805855 -
0.87933536
 -1.24557198 -1.40097437 -0.43251433 -0.5887359  -0.76497975 -
1.11132691
  0.17829515  0.1716258  -0.04274583 -0.39454077  0.49984654
0.20023242
  0.22985357 -0.33888614 -1.16575647 -1.55607902 -1.8359862  -
1.31443433
 -0.82121312 -1.35048043 -1.46039484 -1.10378774]
```

- Fit: Reasonable (errors -7 to 0.5); twist introduces variability.


Average Raw ACF
ACF
1.0
0.8
0.6
0.4
0.2
0.0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Lag



6. Recommendations

Twist credible—higher severe needs capacity; model good, joints essential.