Predicting Patient Volume at Stanford Children's Hospital

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Introduction

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Work presented by Schienker shows loss of value when departments are inaccurately staffed

Goal: to help nursing managers anticipate the flux of patients in their department

Technology stack: SQL Server-Python-Tableau

Data Science Introduction

Why do we need data science?

Only 3 variables: Date, department and census count (= patient volume = ADC = ACC)

Regress on patient volume - forecast 30 days

Goal: forecast patient volume 30 days in advance and improve Mean Absolute Percentage Error to under 15% for each department

Models: ARIMA, RNN, XGBoost

Data: Type, Size, Departments

Very simple dataset

```
Rows 16860
Columns 3
```

Only 3 columns!

	EffectiveDAte	DepartmentName	AverageCensusCount
6139	2016-01-01	COMPREHENSIVE CARE PGM	8
6741	2016-01-01	3 NORTH	10
7901	2016-01-01	F2-MATERNITY	21
4737	2016-01-01	PICN 1	11
4061	2016-01-01	SEQ SPEC CARE NURSERY	4

Extract relevant departments

```
raw_df['DepartmentName'].value_counts()
```

```
COMPREHENSIVE CARE PGM     924
LABOR & DELIVERY           924
SEQ SPEC CARE NURSERY      882
PEDI EL CAMINO             879
NICU 270                   844
HEMATOLOGY/ONCOLOGY        823
```

Data: Statistics

Min is much lower than 25%

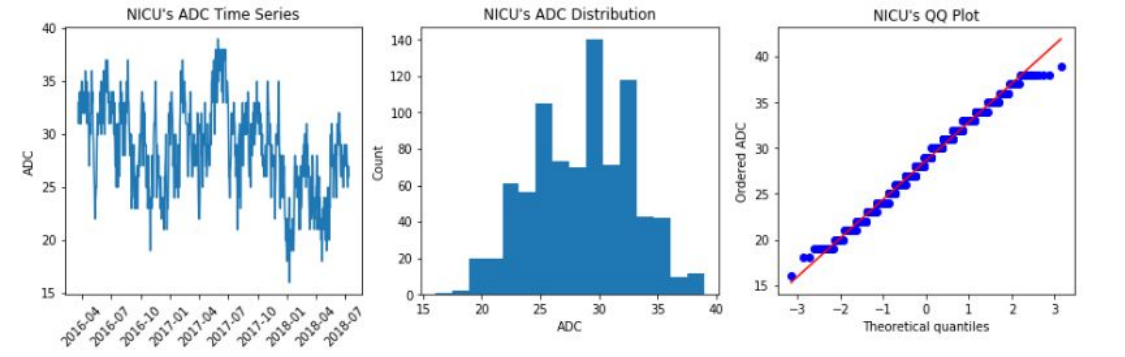
	NICU	CVICU	PICU	PCU
count	844.000000	614.000000	621.000000	2560.000000
mean	28.622038	17.407166	20.713366	14.273828
std	4.240184	2.735248	2.582503	4.700779
min	16.000000	8.000000	11.000000	4.000000
25%	26.000000	16.000000	19.000000	10.000000
50%	29.000000	18.000000	21.000000	14.000000
75%	32.000000	19.000000	23.000000	16.000000
max	39.000000	21.000000	24.000000	26.000000

PCU count is 3x other depts

```
Number of unique dates in PCU group: 858
```

PCU group is made of many small depts

Data: Target Variable



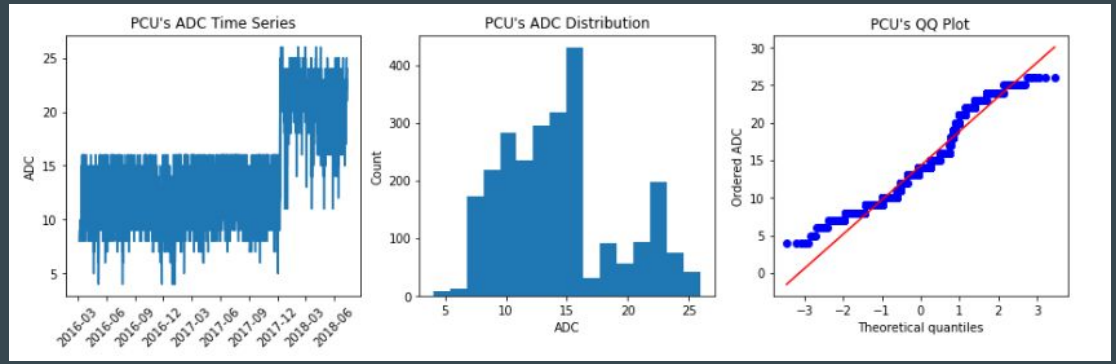
No obvious trend or frequency in time series

Normal distribution

New hospital opened in Dec. 2017

Add boolean feature ‘lpch_main_open’

Keep an eye on low predicted values

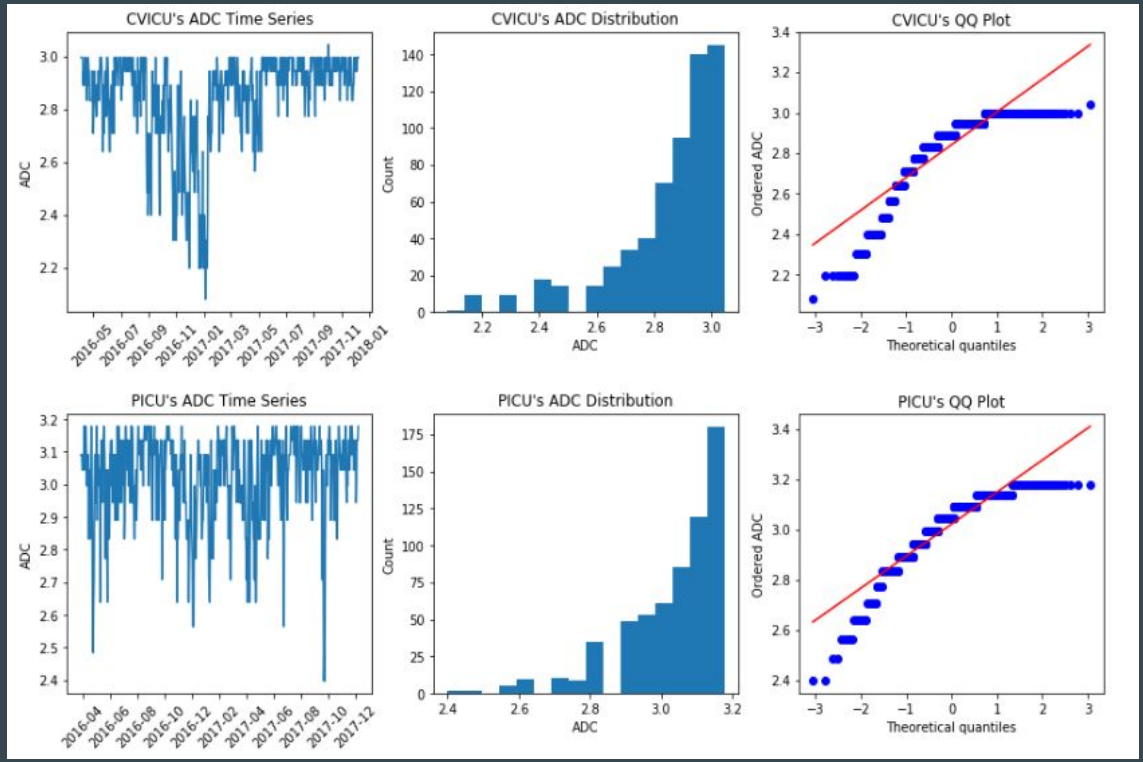


Data: Target Variable

Right skew in CVICU and PICU departments

Non-normal QQ plot

Strong transformation does not change normality

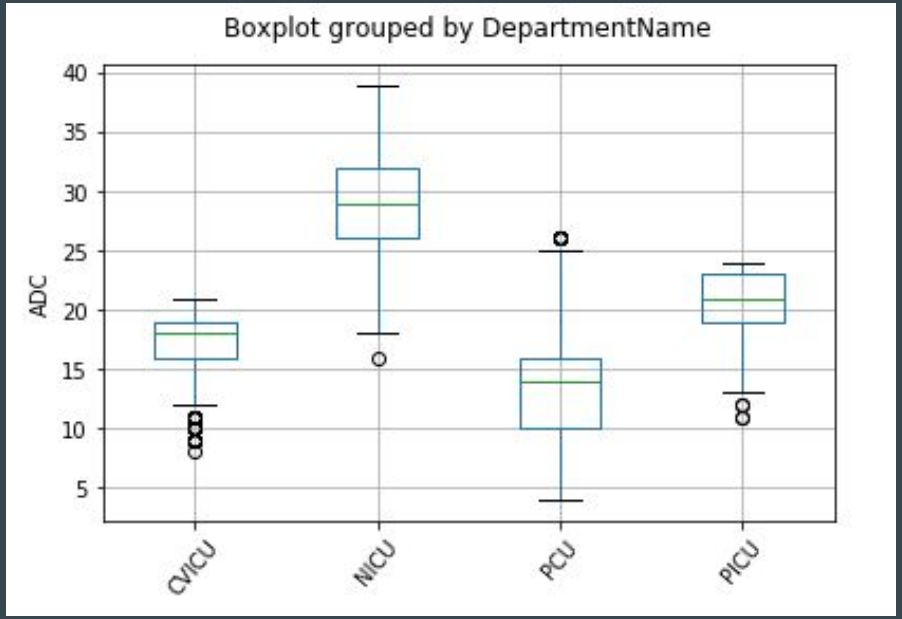


Data: Departments

Few outliers, each department seems unique

Confirmed by T-test results, must model each department separately

```
NICU vs CVICU
t-statistic 57.42       pvalue 0.00e+00

NICU vs PICU
t-statistic 41.19       pvalue 6.43e-247

NICU vs PCU
t-statistic 78.74       pvalue 0.00e+00

CVICU vs PICU
t-statistic -21.84      pvalue 1.12e-89

CVICU vs PCU
t-statistic 15.88       pvalue 1.01e-54

PICU vs PCU
t-statistic 32.95       pvalue 4.28e-205
```

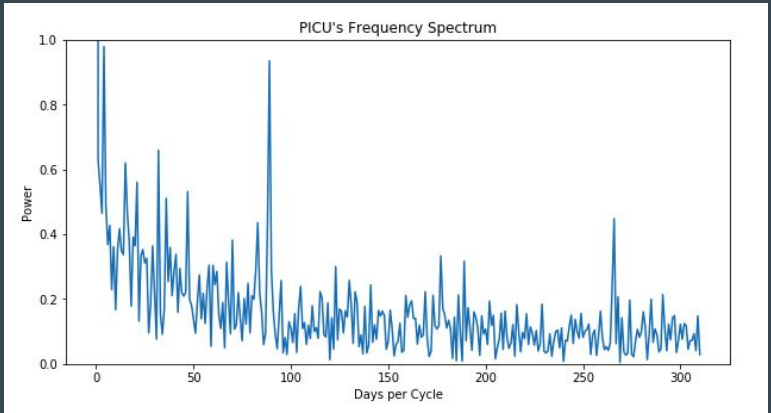


Feature Engineering

ARIMA is simplest, takes time series of values (don't even need the dates!).

RNNs are next easiest, if a row is today, then features are previous m days to today, targets are tomorrow to next n days.

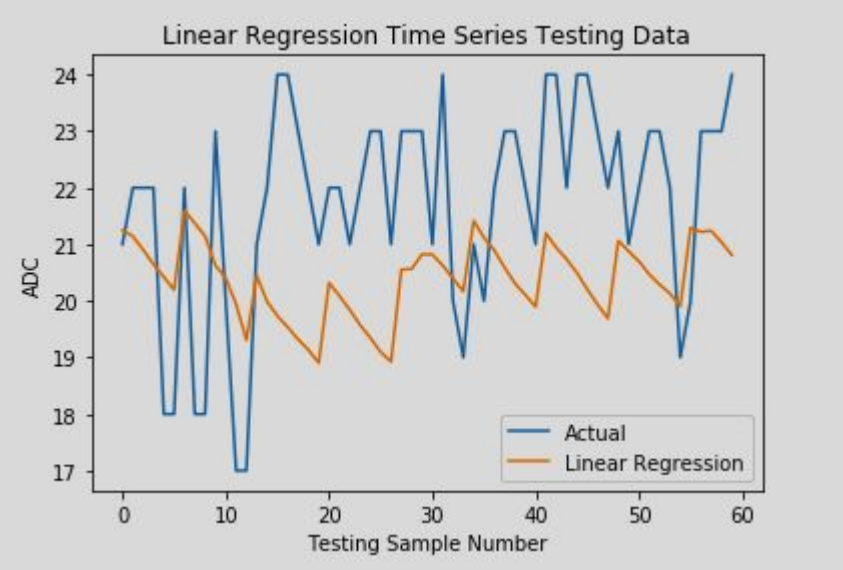
XGBoost is hardest, requires feature engineering with a priori constraints.

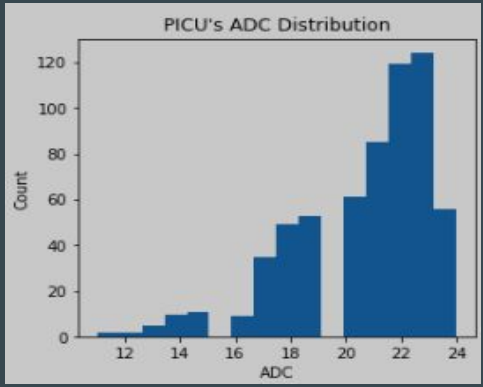


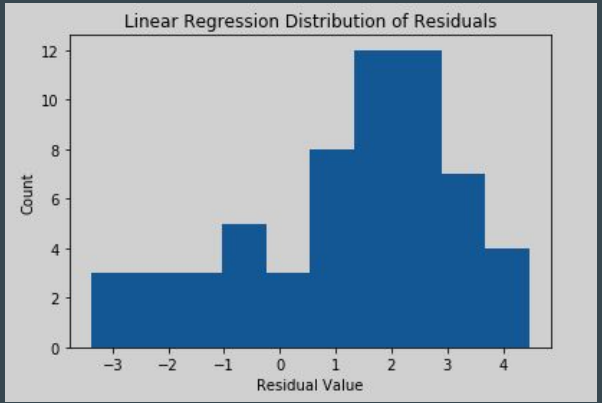

```python
# sequential split
def seq_split(df,window_size=7):
    X = df.copy()
    df_temp = df.copy()
    for i in range(window_size):
        X = pd.concat([df_temp.shift(i+1),X],axis=1)
    return X.dropna(axis=0)
```

Modeling: Baseline (Linear Regression)

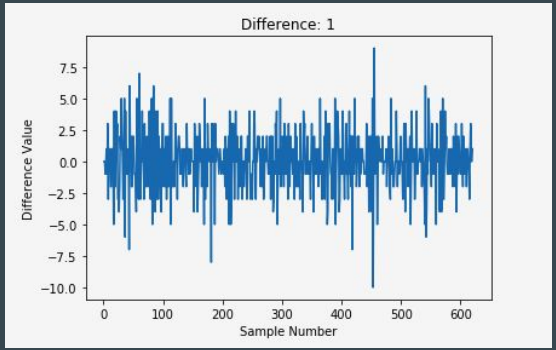
Feature engineering - date values, new hospital boolean, rolling statistics







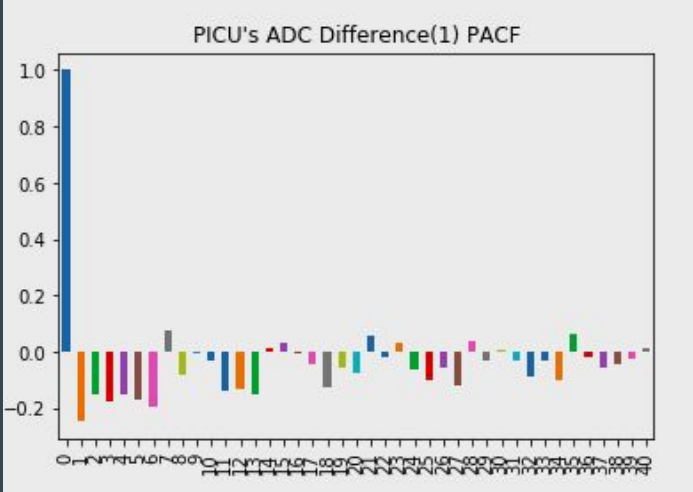
Modeling: ARIMA

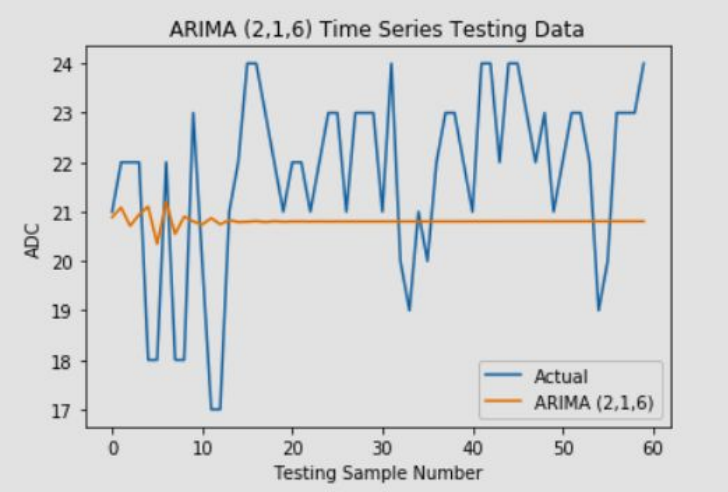


Difference for stationarity

PACF for parametric grid search

(2,1,6) AIC of 2671



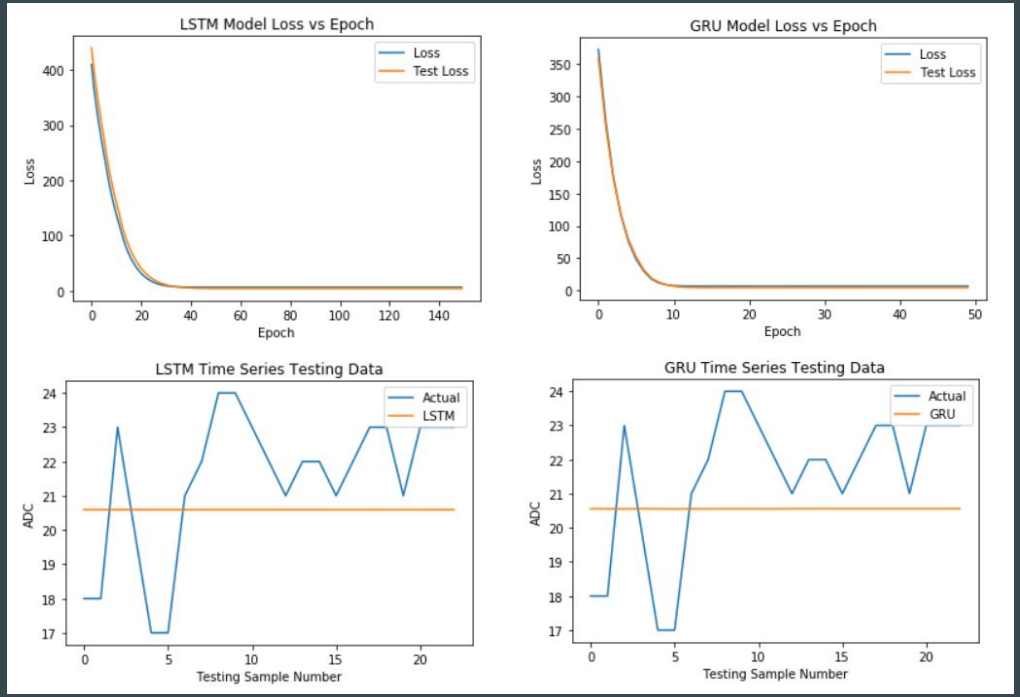


Modeling: RNNs

GRU (Gated Recurrent Unit)

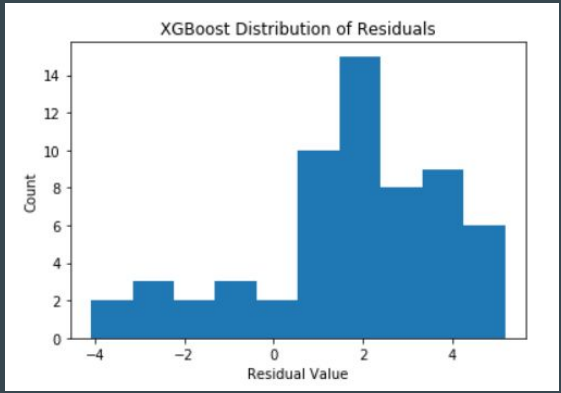
LSTM (Long Short Term Memory)

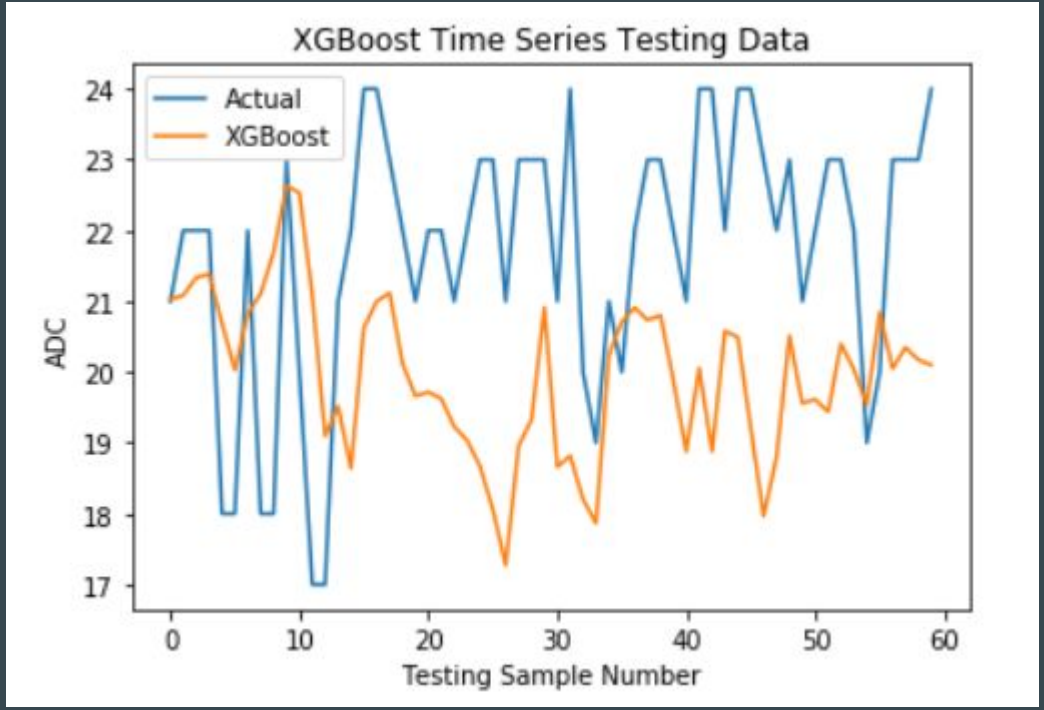
	Width	Epochs	Batch Size
GRU	64	50	8
LSTM	32	150	8



Modeling: XGBoost

Train on random splitting of data - more versatile, assumes patient volume does not depend on a short term sequence, but rather the properties of a given day





Evaluation

ARIMA is most accurate

RNNs take the longest to train

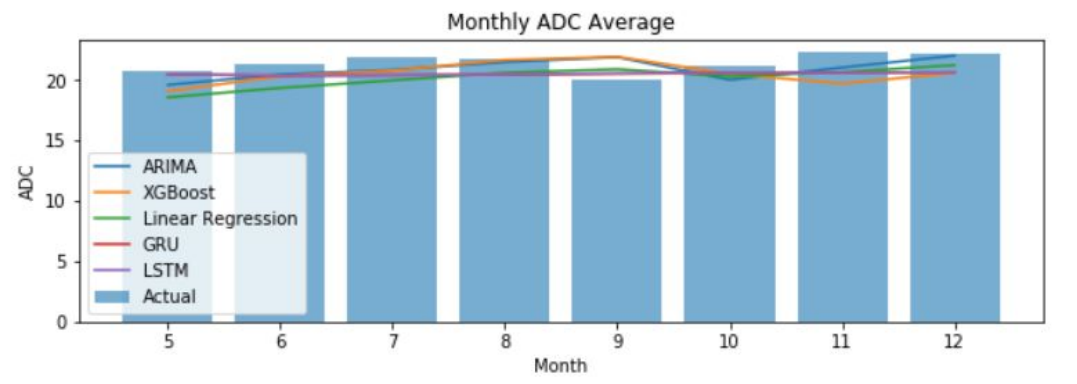
XGBoost and linear regression show adaptability

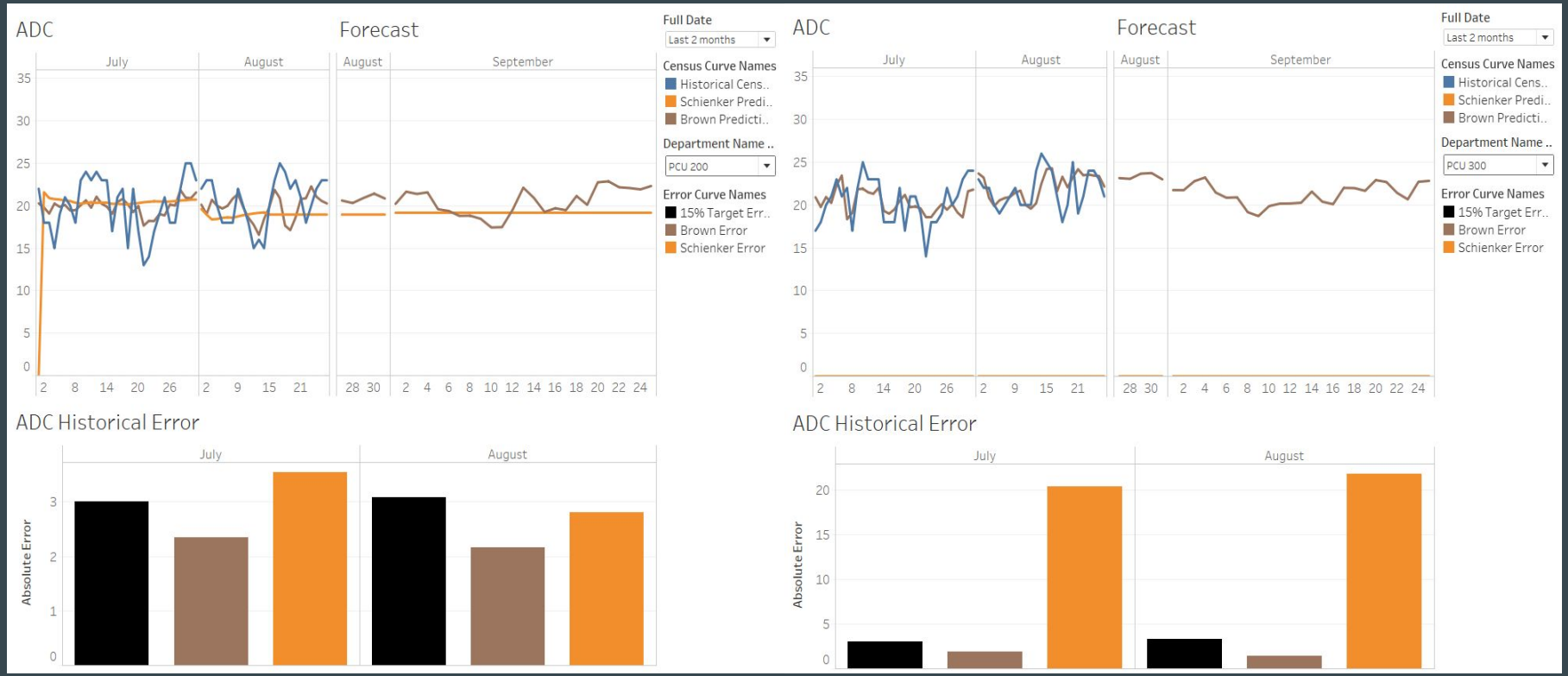
ARIMA only has short term (~10 days) adaptability

XGBoost has most adaptability and error within constraints

Target (Under 15% MAPE)	3.209
ARIMA	0.956 +/- 0.565
XGBoost	1.308 +/- 0.765
LinReg	1.425 +/- 0.535
GRU	1.024 +/- 0.544
LSTM	1.023 +/- 0.537

Average Training Time in seconds	
ARIMA	2.793283
XGB	0.115379
LinReg	0.001510
GRU	9.562463
LSTM	23.730989




ADC
Forecast
July
August
August
September
35
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25
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Full Date
Last 2 months
Census Curve Names
Historical Cens..
Schienker Predi..
Brown Predicti..
Department Name ..
PCU 200
Error Curve Names
15% Target Err..
Brown Error
Schienker Error
ADC Historical Error
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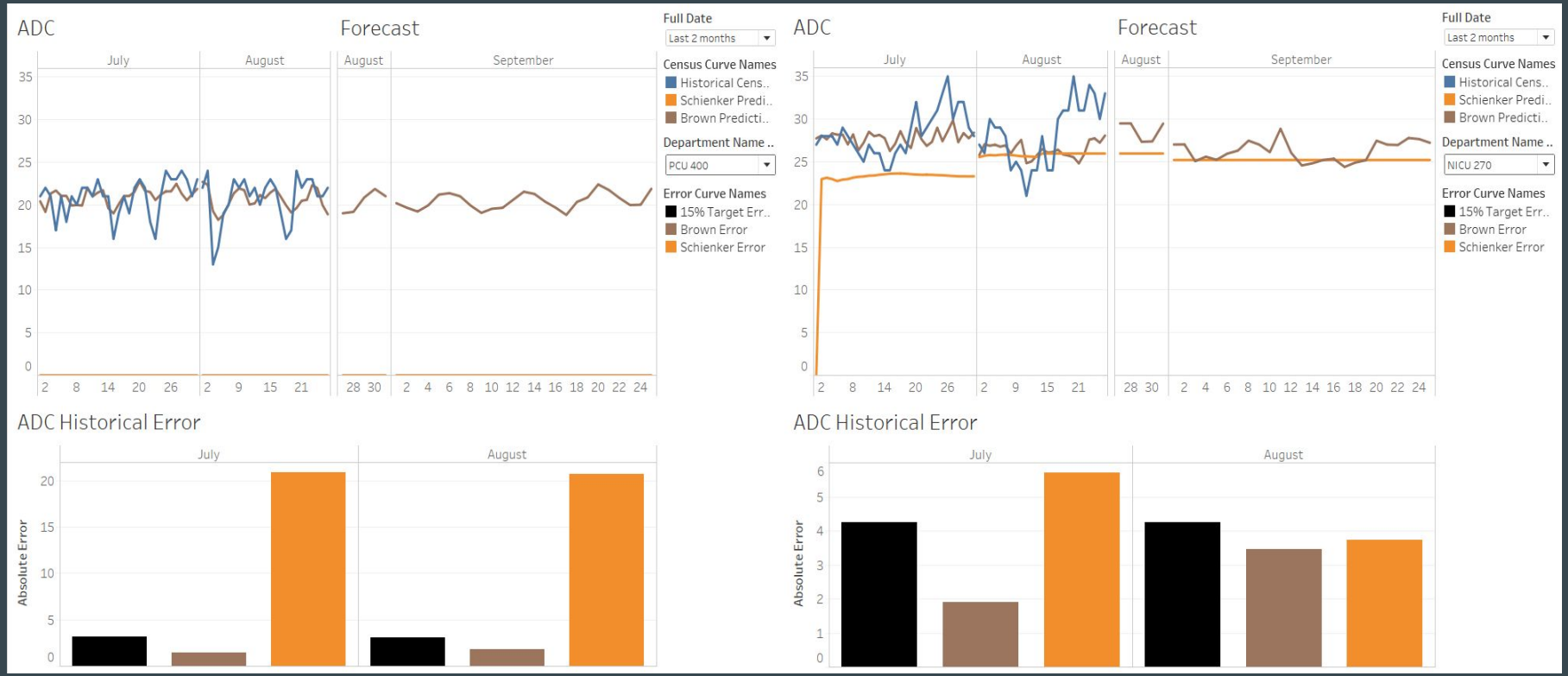
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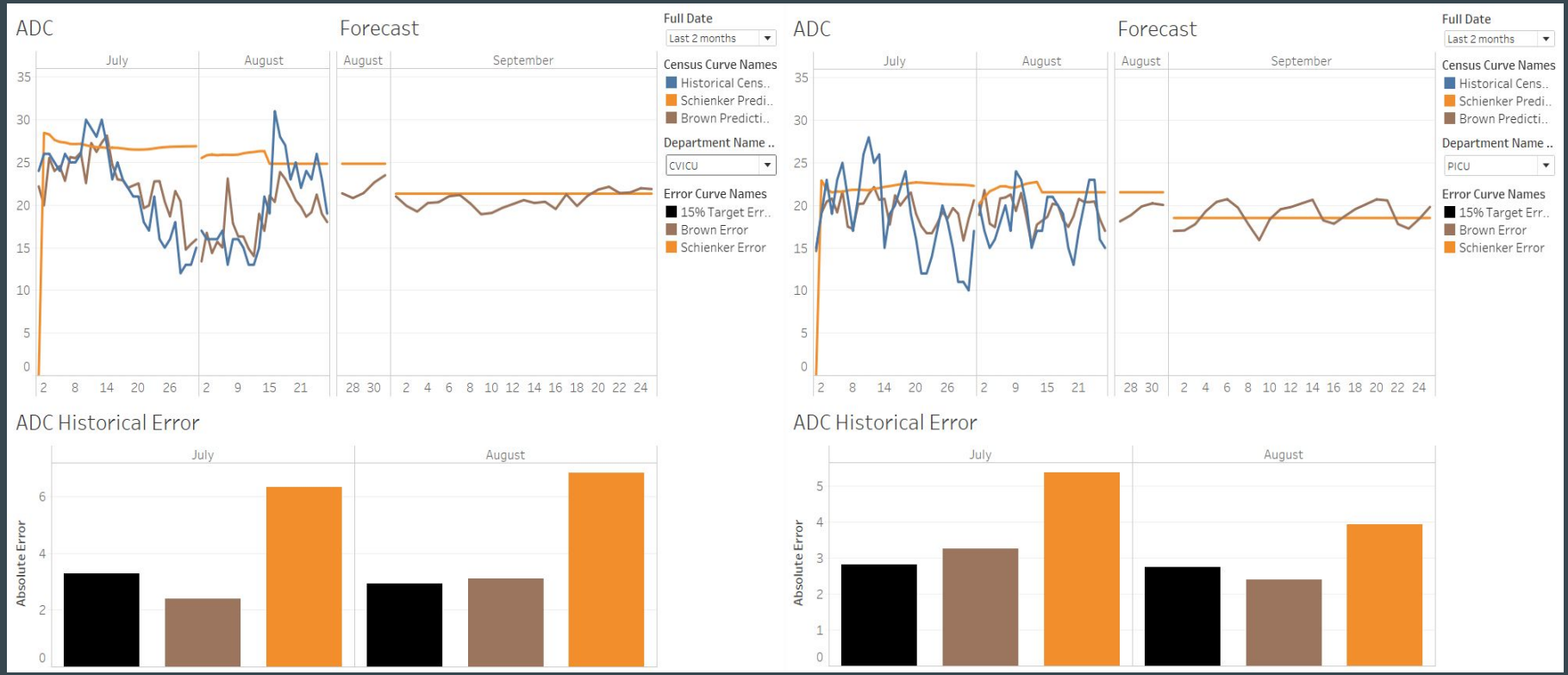
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Brown Predicti..
Department Name ..
PICU
Error Curve Names
15% Target Err..
Brown Error
Schienker Error
ADC Historical Error
Absolute Error

Deployment

Model.py

Job.py

Schedule.py

Run Schedule.bat

```
def schienker_predictions(df):
def xgb_features(df):
def xgb_train(df_xgb):
def open_connection():
def df_to_sql(df):
```

```
def query_to_df():
def iter_job(i=0):
def job(j=0):
```

```
from Job import job
import schedule
import time

if __name__ == '__main__':
    schedule.every().day.at("4:00").do(job)
    while True:
        schedule.run_pending()
        time.sleep(3600)
```

```
@echo off
py Schedule.py
pause
```

Thanks!

Brendan Watkins, Ganga Palakkatil

Dave Samuel