Traffic, Weather, & Incidents in Nashville, TN

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Introduction

- Incident Response is a challenge faced by communities across the globe.
- Globally, about 3,200 people die every day from road accidents alone, leading to a total of 1.25 million deaths annually
- Furthermore, accidents can cause traffic and congestion
- We want to analyze the incidents, and their relationship with response time, traffic, and weather.

Data Sets

- Incidents
  - Data of all of the incidents which occurred in Nashville from 2017-2021
- Roads
  - Data of all roadways in Tennessee
  - Gives info such as length of roadway, number of lanes, etc.
- Traffic
  - Gives traffic data across Nashville
- Weather
  - Weather data across Nashville. Weather in each area, precipitation, etc.

Technologies Used

- Storing and loading data
  - S3 to store original and merged data sets
- Transforming data
  - Spark with EMR to add window column
- Querying data
  - Athena
- Visualization
  - Pandas to load result of queries
  - Plotly to generate maps and graphs
- Machine learning
  - Spark with EMR to run models

Sample Queries

1. SELECT xdgroup, COUNT(distinct id_original) as cnt, AVG(congestion) as cong
   FROM "incidents"."merge" where xdgroup != 0
   GROUP BY xdgroup ORDER BY cnt DESC, cong DESC LIMIT 20;

2. SELECT COUNT(distinct incident_id) as num_incidents, AVG(response_time_sec) as avg_response,
   AVG(speed) as avg_speed, hour_of_day
   FROM "incidents"."merge" WHERE xdgroup in (SELECT xdgroup FROM "incidents"."top20" as t20)
   GROUP BY hour_of_day ORDER BY hour_of_day;

3. SELECT COUNT(incident_id) as num_incident, temp_range, AVG(avg_response) as response,
   AVG(avg_speed) as speed, AVG(avg_congestion) as cong
   FROM (SELECT *, CAST(FLOOR(avg_temp/10) as INT) as INT) temp_range FROM "incidents"."weather")
   GROUP BY temp_range ORDER BY temp_range;

4. SELECT COUNT(distinct incident_id) as num_incidents, month
   FROM (SELECT * FROM "incidents"."merge"
   WHERE latitude >= 36.13 AND latitude < 36.15 AND longitude >= -86.81 AND longitude < -86.79)
   GROUP BY month ORDER BY month;

Sample Results

Query 1: Top 20 Roadways

	xdgroup	cnt	cong
1	2858287	623	0.15202679436521624
2	1746789	377	0.08957439740297297
3	1743946	356	0.10160349472945007
4	1621379	340	0.12447910501136183
5	1740471	238	0.10180981537258228
6	1681622	237	
7	2860921	232	
8	3177417	222	
9	3176773	219	
10	1722191	218	
11	1627331	216	

Query 2: Incident Statistics by Hour

	num_incidents	avg_response	avg_speed	hour_of_day
1	110	403.53636363636366	49.85473737373736	0
2	104	448.44005358338916	54.87695378432684	1
3	115	514.7913043478261	50.82140700483088	2
4	100	471.0251051893408	54.766370266479655	3
5	78	434.69005010737294	56.06633500357912	4
6	138	420.8027998791419	56.72735220062441	5
7	209	411.79514143094843	47.26504159733775	6
8	212	391.31253277399054	47.3891033036182	7
9	174	406.3735632183908	46.3839750957854	8
10	159	391.50314465408803	44.568080887491234	9
11	177	378.01483167229065	46.44047006199475	10
12	227	391.15859030837004	46.1140363436123	11

Sample Results (Cont'd.)

Query 3: Incident Statistics by Temperature Range

	num_incident	temp_range	avg_response	avg_speed	avg_conges
2	386	-1	400.97668393782385	37.95402752810969	0.11222674
3	3214	0	381.3453640323584	36.960817155673716	0.11476722
4	4383	1	372.6390600045631	36.50840666420556	0.11988138
5	5294	2	361.5521344918776	37.19889814320872	0.11488573
6	1299	3	367.75365665896845	33.70927520048498	0.16693998

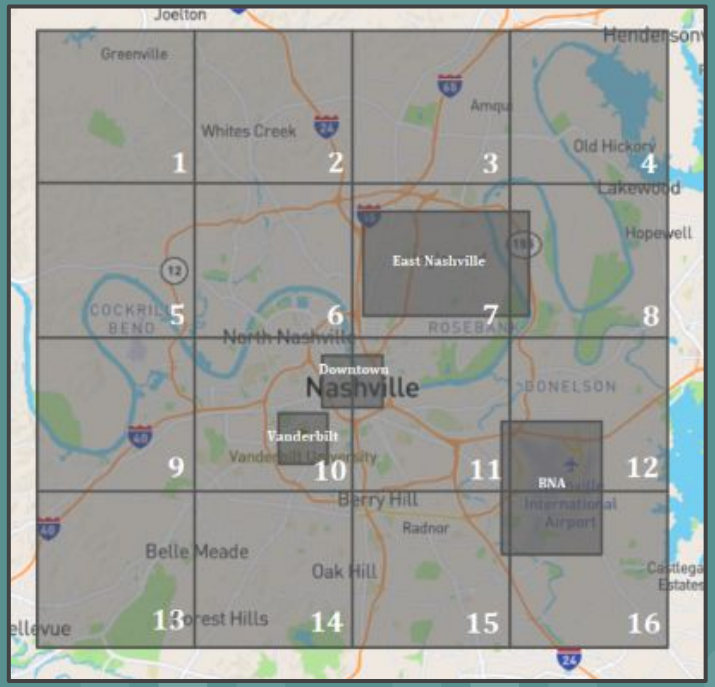
Temperature Range	
-1	-10 °C to 0 °C
0	0 °C to 10 °C
1	10 °C to 20 °C
2	20 °C to 30 °C
3	30 °C +

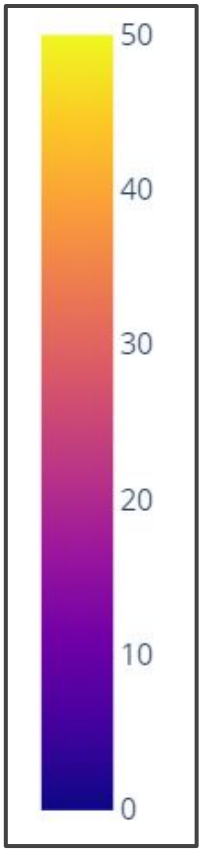
Query 4: Vanderbilt Incident Frequency by Month

num_incidents	month
15	1
9	2
7	3
7	4
9	5
13	6
16	7
28	8
12	9
19	10
6	11
10	12

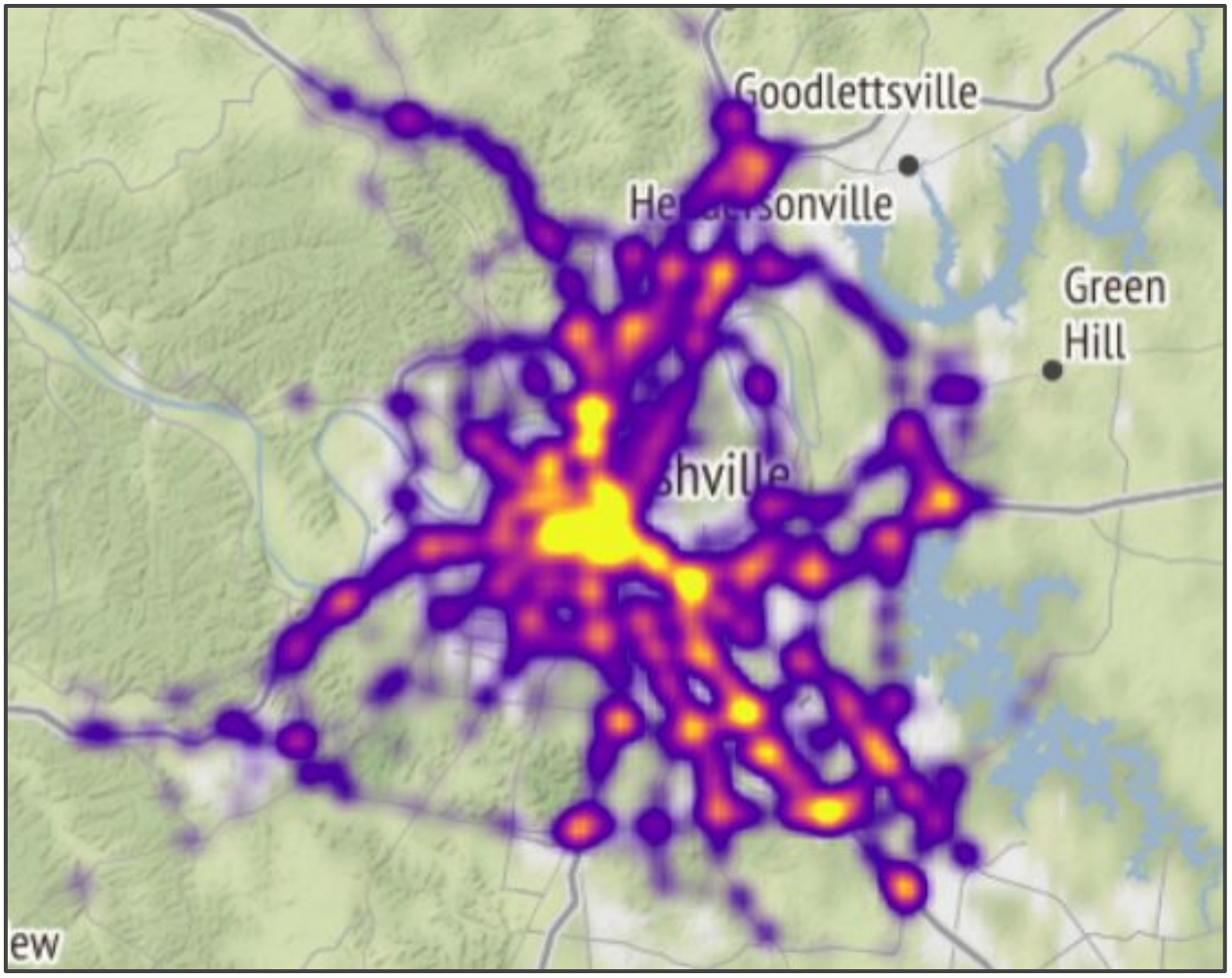
Machine Learning

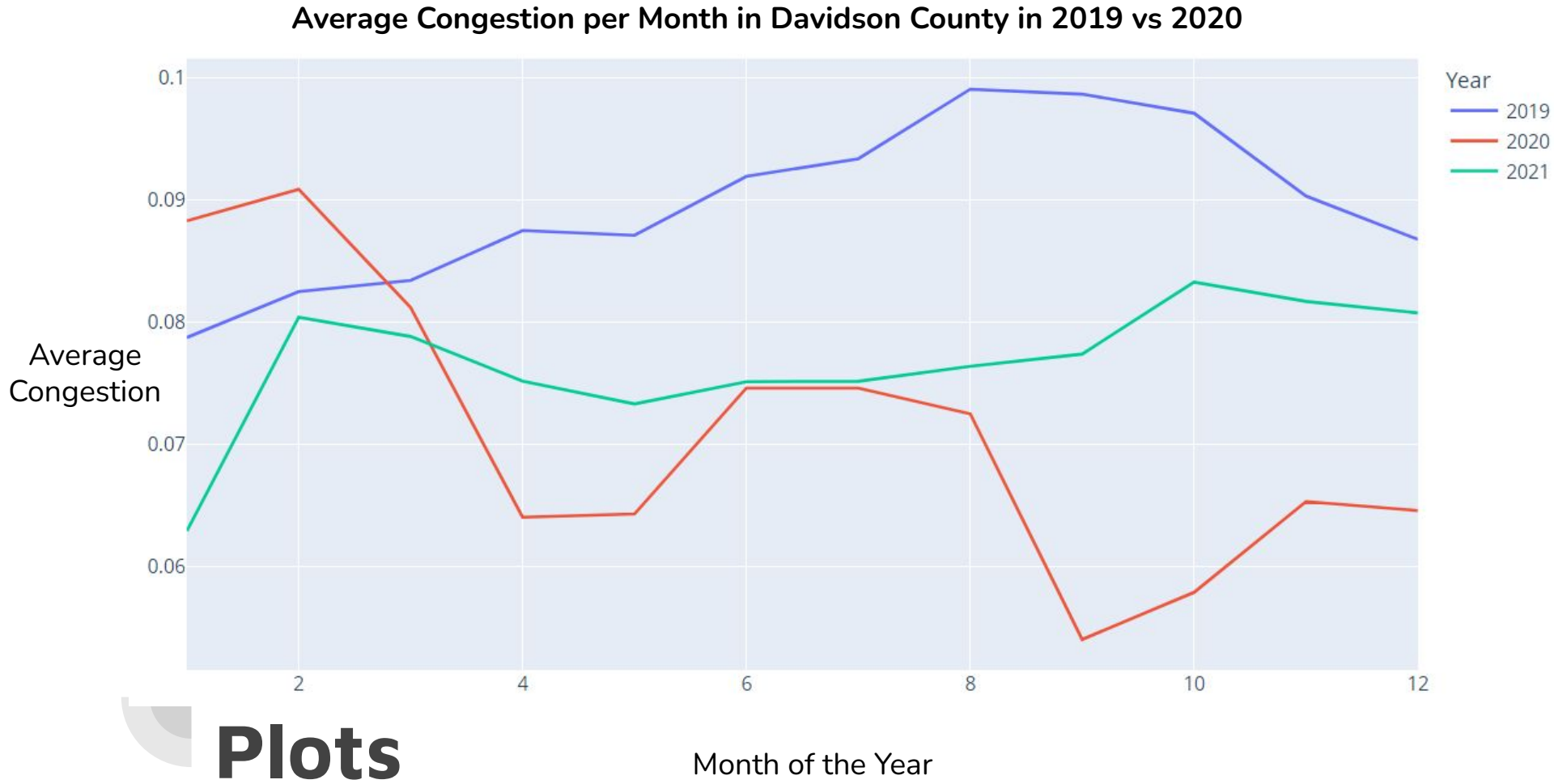
Area of grid	Linear Regression RMSE	Random Forest Regression RMSE	Gradient Boosted Tree Regression RMSE	Lowest RMSE Regressor's Prediction
Q1	0.5369	0.8814	**0.5**	1
Q2	**1.6988**	1.83868	1.7388	5.33
Q3	10.914	**5.7268**	11.187	24.2
Q4	**2.499**	2.848	2.965	6.49
Q5	1.929	**1.456**	1.732	2.5
Q6	13.559	**5.552**	8.503	20.6
Q7	19.96	**7.439**	10.583	40.95





Plots




Average Congestion per Month in Davidson County in 2019 vs 2020
Average Congestion
0.1
0.09
0.08
0.07
0.06
2
4
6
8
10
12
Month of the Year
Year
2019
2020
2021

Plots


Average Speed per Hour on T20 roadways in Davidson County in 2019 vs 2020
Year
2019
2020
Average Speed (miles per hour)
55
50
45
40
0
5
10
15
20
Hour of the Day

Plots

Implications

- **Time Implications**
  - Congestion/speed depends on time of day, day of week, etc
  - COVID more or less *didn't* affect the number of incidents on Nashville roadways (2019 vs 2020)
  - *Most* accidents happen at 5pm (rush hour), least happen at 6am
  - Friday and Saturday are the busiest (and most accident-prone) days to be driving!
- **Weather Implications**
  - *Most* accidents happen in 20-30 degrees Celsius
  - Counterintuitively, lower visibility does *not* lead to more accidents
    - Perhaps because Nashville has good visibility year-round and/or drivers are more careful when visibility is low, since this is when congestion is *highest*
  - Response Time inv. prop. to precipitation; prop. to temperature & visibility
- **Location-Specific Implications**
  - Certain areas in Nashville are more prone to incidents
  - **Downtown** is ¼ the size of **East Nashville**, but has twice as many accidents
  - In **Vanderbilt**, the first semester of school (months) have the highest incident frequency
  - During summer vacation months and winter break, **BNA** has the most accidents
  - In the afternoon hours (12-2pm) and after 7pm, **Downtown** has the most accidents
    - Lunch break? College nightlife?

References

[1] Learning Incident Prediction Models Over Large Geographical Areas for Emergency Response Systems

[2] A Review of Incident Prediction, Resource Allocation, and Dispatch Models for Emergency Management