CS 179: Intro to Graphical Models

CS 179 Report

Final Project

Markov Model Interstate Traffic

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Introduction

In this project, I used the Markov Model to learn about weather patterns. I essentially made a model that analyzed how weather changed over time. I achieved this through a series of hidden states that depicted a weather type such as being clear or cloudy. The goal was to be able to recognize patterns in weather data and analyze how patterns changed depending on data size or model complexity. I made use of public data saved in an excel spreadsheet for data collection.

Resources Used

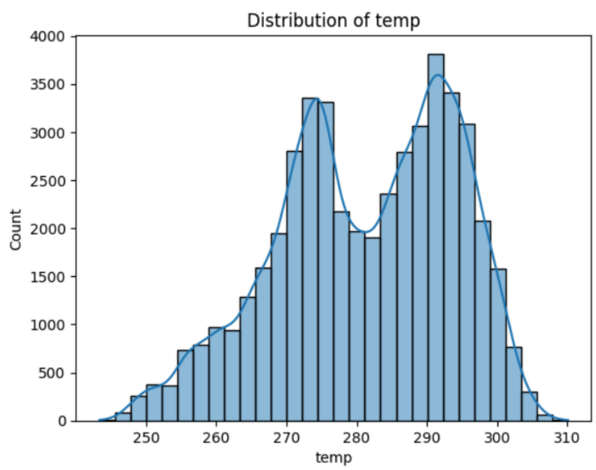
In terms of the data collected, I used the Metro Interstate Traffic Volume dataset which is provided by UCI for machine learning purposes. The data provides data in terms of traffic, as well as, weather. I focused more on weather patterns. The data uses weather patterns from Minneapolis-St Paul westbound I-94 from the dates 2012-2018. I made sure to process and load the data by extracting it from the download .csv file. I focused on temperature and cloud cover percentage. The images below depict the data pulled from the .csv file in a visually concise manner.

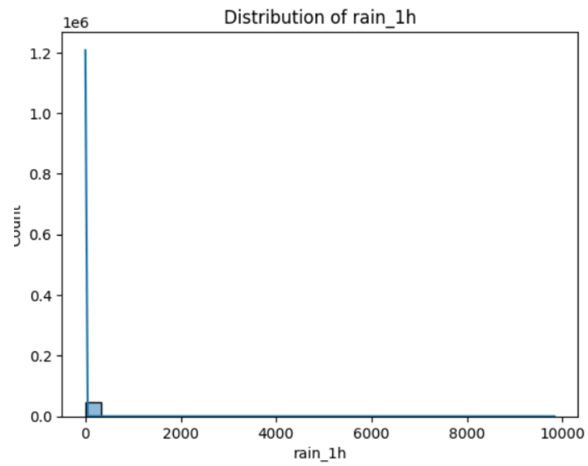
Normalized data sample:

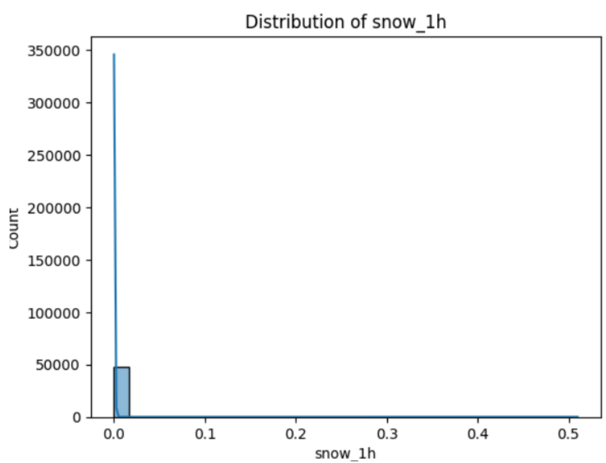
	date_time	temp	rain_1h	snow_1h	clouds_all	weather_main
0	2012-10-02 09:00:00	0.552013	-0.007464	-0.027231	-0.240240	Clouds
1	2012-10-02 10:00:00	0.636989	-0.007464	-0.027231	0.656899	Clouds
2	2012-10-02 11:00:00	0.654299	-0.007464	-0.027231	1.041387	Clouds
3	2012-10-02 12:00:00	0.697574	-0.007464	-0.027231	1.041387	Clouds
4	2012-10-02 13:00:00	0.777042	-0.007464	-0.027231	0.656899	Clouds

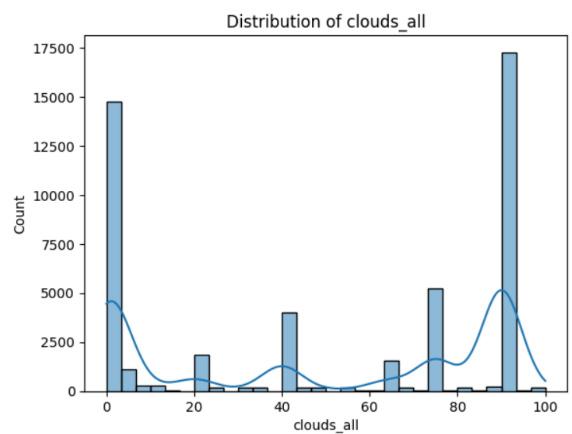
Discretized data sample:

	date_time	temp	rain_1h	snow_1h	clouds_all	weather_main
0	2012-10-02 09:00:00	3.0	0.0	0.0	2.0	Clouds
1	2012-10-02 10:00:00	3.0	0.0	0.0	3.0	Clouds
2	2012-10-02 11:00:00	3.0	0.0	0.0	4.0	Clouds
3	2012-10-02 12:00:00	3.0	0.0	0.0	4.0	Clouds
4	2012-10-02 13:00:00	3.0	0.0	0.0	3.0	Clouds







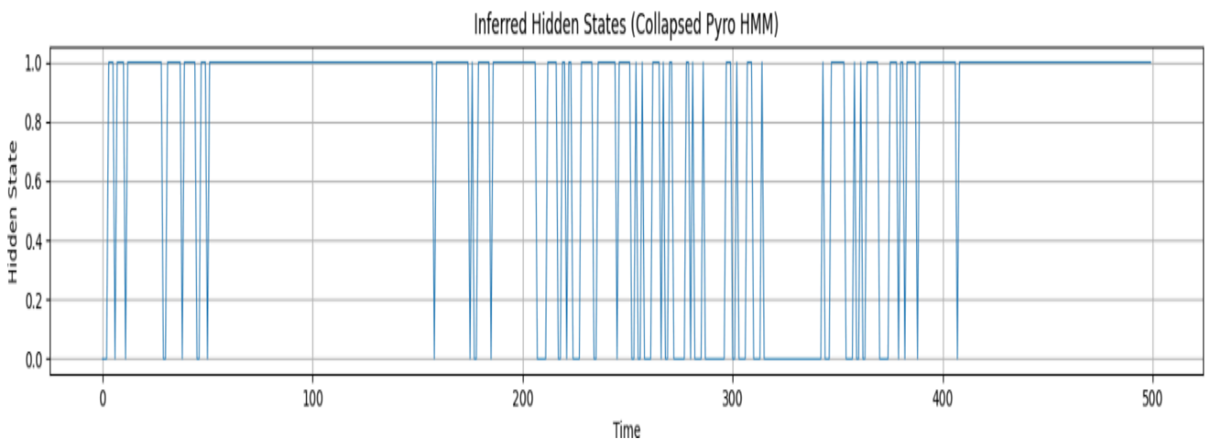


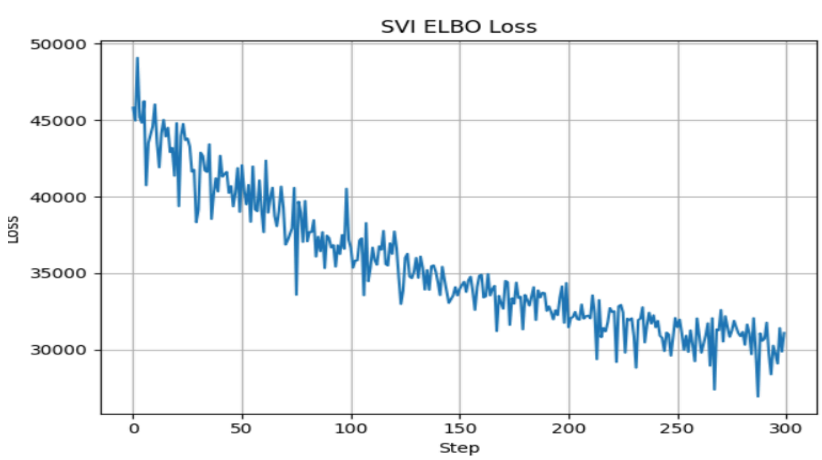
As depicted by the data images, we see how different weather types carry highly unique characteristics. We see how temperature follows a bimodal distribution while snow and rain are extremely scarce. These unique distributions are important to note when measuring weather probabilities.

Furthermore, I implemented the model using the Pyro library. Pyro is great for probability and is a library provided by PyTorch. I took inspiration from Diksha Khiatani and Ghose Udayan's report on Markov Models to come up with the idea of using a Markov model for weather forecasting. My approach used a simple Markov Model with use of the Pyro built in functions.

Evaluation Techniques

One way that I analyzed performance is by first comparing model complexity and data size. In a rush for testing, I implemented a simple Markov Model that uses a very small data size. The model simply showed the inferred hidden state whether it scored true with one or false with 0. Not much can be inferred from this model. I then proceeded to a more complex model that used the full data size which depicts the loss overtime from steps taken. This provided much more insight on the role of data size. The graphs below show a comparison between the two model outputs. On the left is the simple model output and the right shows the loss to step relationship of a full data analysis.





I also focused on how different states got assigned when running the markov model. Understanding the frequency of state assignment allows me to see how the model is predicting over the course of it's iterations. I found that the first state was chosen 25% of the time while the second state was imposed 50% of the time. Furthermore, I looked into transitions to see how frequent jumping between states was occurring. Similar to state assignment, we see similar ratios as depicted in the graphs below.

State Summary:

	State	Count	Proportion
0	0	128	0.256
1	1	372	0.744
2	2	0	0.000

Transition Matrix:

	From	To_0	To_1	To_2
0	From_0	41	87	0
1	From_1	86	285	0
2	From_2	0	0	0

Conclusion

In essence, the results help show that a Markov Model does an excellent job at structuring weather patterns by finding dominating traits and mapping predictions over the course of several iterations. It was found that hidden states followed dominant patterns such as weather with high probability or more frequent as shown in data distributions. With that being said, we did see that excess states proved unproductive with returns reaching a 0% reach. We find that 3 states is sufficient for a sample of the data size.

We see that our data set worked well with a simple model. For future work, introducing new weather patterns could help provide more interesting results. We could also apply more probabilistic analyses to show likely forecasts in current years.

Works Cited

Hogue, John. "Metro Interstate Traffic Volume." UCI Machine Learning Repository, 2019, https://doi.org/10.24432/C5X60B.

Khiatani, Diksha, and Udayan Ghose. "Weather forecasting using hidden Markov model." 2017 International Conference on computing and communication technologies for smart nation (IC3TSN). IEEE, 2017.