Analyzing COVID-19 Data By Means of Fast Fourier Transforms Through Autoencoders

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Overview

- SARS-CoV-2 (COVID-19) pandemic has created extremely large and complex data sets (availability presents its own challenges).
- Distilling dense-information rich transformed data.
- Seeking fruitful insight from the salient features of the data.
- Reduce the complexity (dimensionality) of the data while maintaining the integrity of original data using machine learning autoencoder methods.
- Using an autoencoding process and mathematical modeling by means of Fast Fourier Transform and low pass filtering.

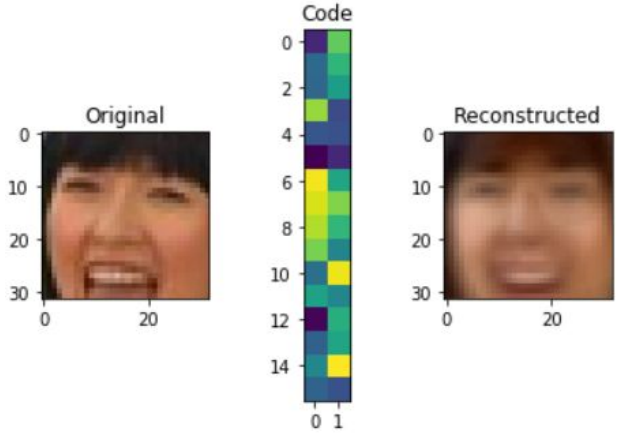
Related Work

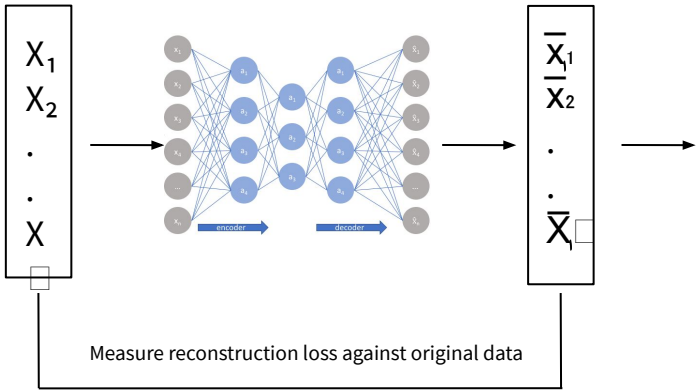
- In a related study in the Journal of Robotics, Networking and Artificial Life, Yokkampon, Umaporn, et al. proposes an autoencoder method with spiking raw data to the frequency domain.
    - Analyze and predict the anomaly case among the standard data set and compare with original data (data set was real-world data from factory automation).
    - The combination of frequency domain and original data has the potential to improve the validity and accuracy in detecting anomalies.
    - Concluded that anomaly detection improves accuracy. Therefore, analyzing time-series data in the frequency domain can be efficient in detecting anomalies for time series data.

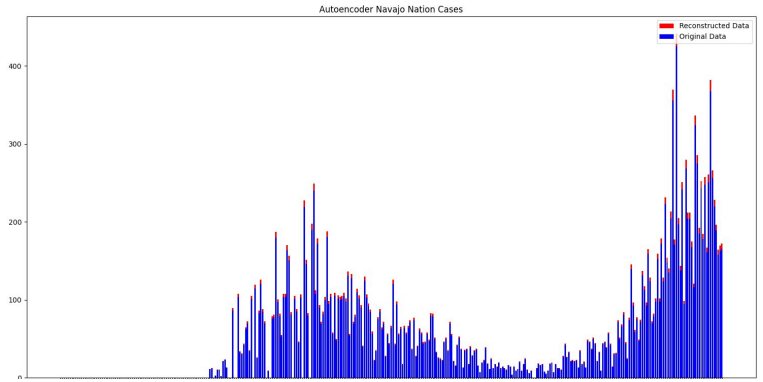
Image source: https://stackabuse.com/autoencoders-for-image-reconstruction-in-python-and-keras/

“What Is An Autoencoder?”

An autoencoder is an **unsupervised artificial neural network** that learns how to compress and encode data. It does this to “learn” how to reconstruct the data back from the **reduced encoded representation** to a representation that is as close to the original input as possible. It works in two key parts: **encoder** and **decoder**.

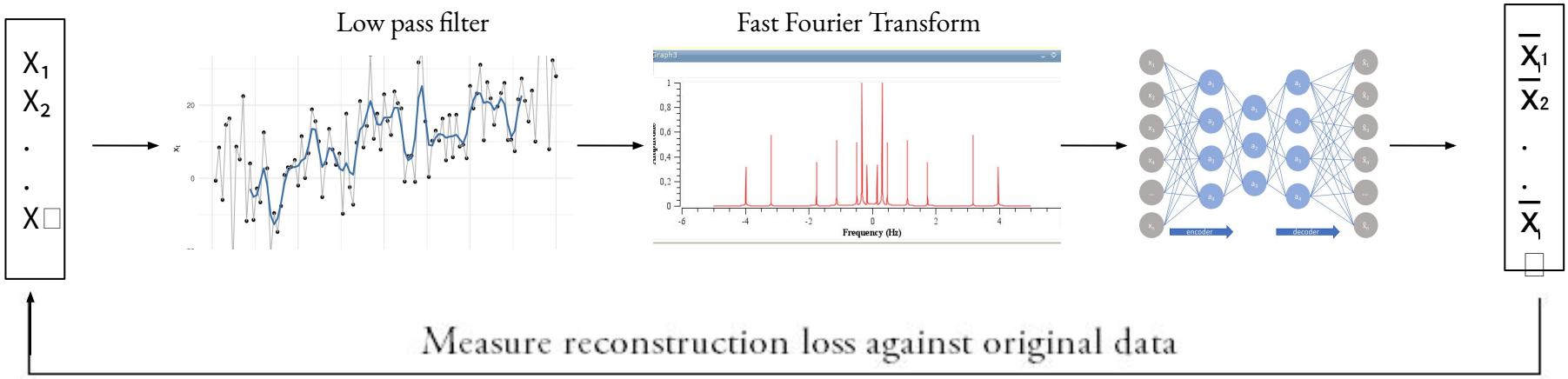




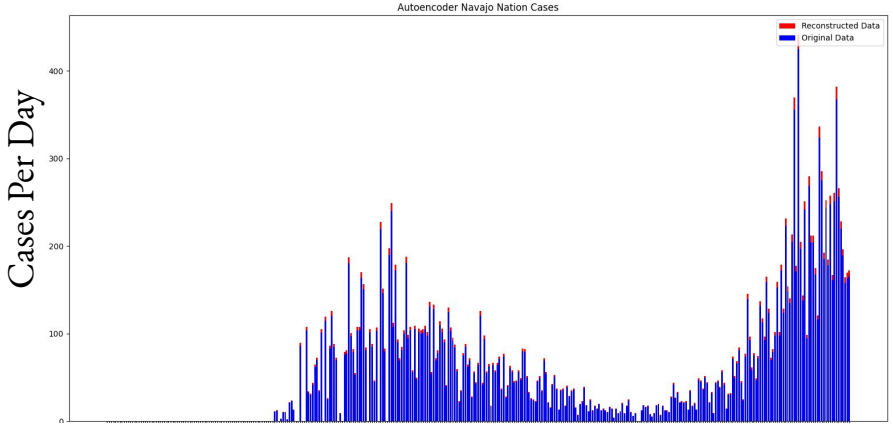


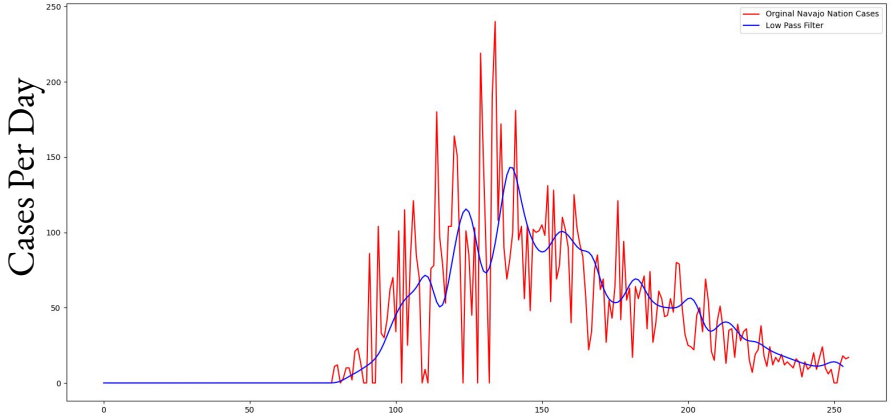
Methods

- Using an autoencoder neural network, the data is deconstructed, compressed, and reconstructed
- This provides the neural network a way to **learn** a representation of the data.
- Using **low pass filters** distills and removes **noise** from the original dataset.
- Utilizing **Fast Fourier Transform** enables the conversion into a **frequency domain** so that the data can be further analyzed.



Observing the Deconstruction and Reconstruction of the Original Data

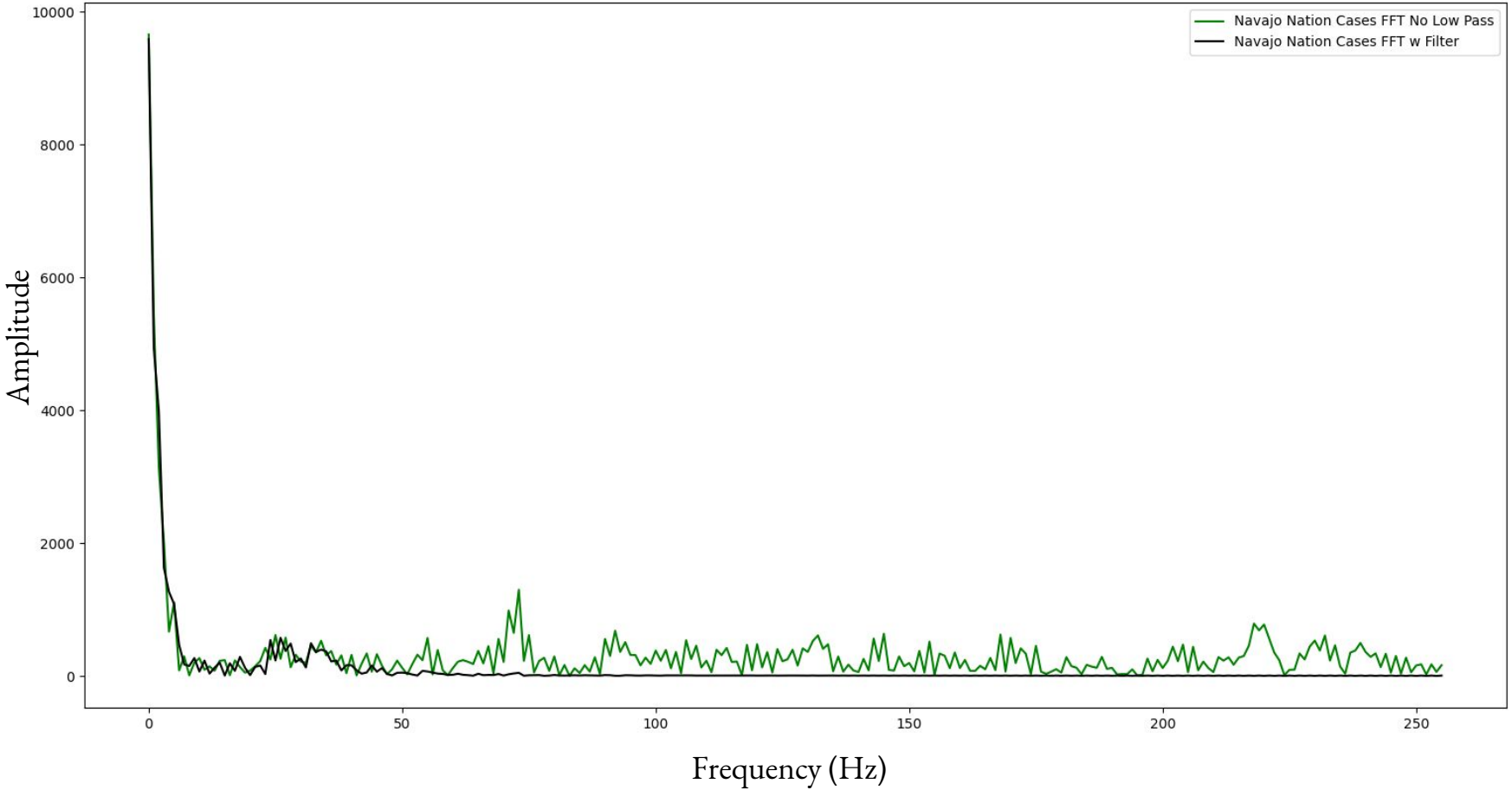




<<<Iterations by day>>>

- The data in this study was collected by day from the Navajo Nation's Dept. of Health
- Reconstructing the original data through the AE
- Passing the original data through a low pass filter to distill the raw data.
- Transform the filtered data to a frequency domain using a Fast Fourier Transform.

Transforming The Data



Conclusions

- Thus far the autoencoder was able to deconstruct and reconstruct the original data set and learn a representation of data.

- The data was able to be passed through a low pass filter and then converted to a frequency domain (Fast Fourier Transform).

- We have been able to reduce the dimensionality of the dataset, extracting real information from the complex domain.

- Observation and analysis of the frequency state is still in process before converting the data back to the time and space domain.

Future Work

- Convert the reconstructed frequency state data back to the time and space domain. (conversion not reversion).

- Combine with original data with the Fast Fourier Transform values.

- Develop and model a metric, as did Yokkampon, Umaporn, et al., for performance evaluation of the accuracy of anomaly detection. Detecting anomalies will be instrumental in testing policy and what was working and not working over the span of the time domain.

- Determine that the data is suitable for forecasting (SIR analysis, QSIR, etc.)

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Acknowledgements

- NSF DMR 2031548 (RAPID)
- NSF DMR 1523611 (PREM)

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