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KNIME

Moving into the Frequency Domain with the Fourier Transform

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5-6pm Berlin

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Before We Start

- Agenda
  - Webinar - 45 minutes – 5 pm Berlin / 11 am Austin
  - Q&A - 15 minutes – 5:45 pm Berlin / 11:45 am Austin
- Ask your questions in the Q&A
- Session is recorded and will be available on YouTube
- Slides will be available as well on the KNIME Forum
- Example workflow is available on the KNIME Hub

Agenda

- Data Transforms
  - +1 and -1 undoes it
- The Fourier Transform
  - Kind of like Taylor Series with sine waves
- The Frequency Domain
  - Amplitudes of component sine waves
- Why, Where, and How?
- Dimensionality Reduction
  - Many frequency columns created by FFT
- Modeling
  - Numeric inputs, cross sectional data
- Questions

What is a Transform?

- Changes the representation of our data
- For example, a point on the plane can be represented by an (x,y) pair or by a (θ,r) pair.
- Transforms simply allow us to move our data points from one representation to another.
- Reversibility is a nice, but not always practical feature of transforms.

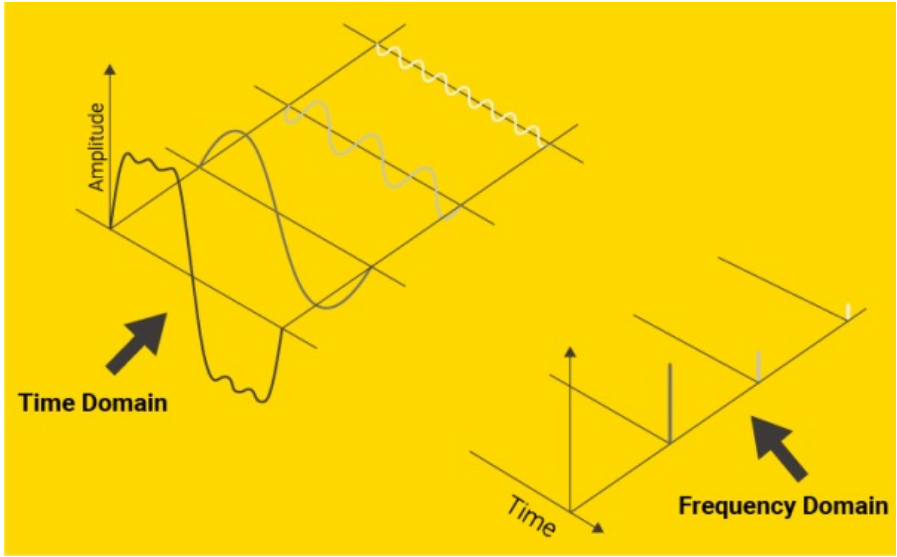
The Fourier Transform

$$x'_k = \sum_{0}^{N-1} x_k \cdot e^{-\frac{i2\pi}{N}kn}$$

- Imagine we have many sine waves with varying frequencies.
- Then we take each wave and assign it an amplitude based on how strongly it corresponds(dot product) to our signal.
- Representing our raw signal as a sum of this sine waves is the Fourier Transform.
- When we look at these amplitudes, we're looking at the Frequency Domain.

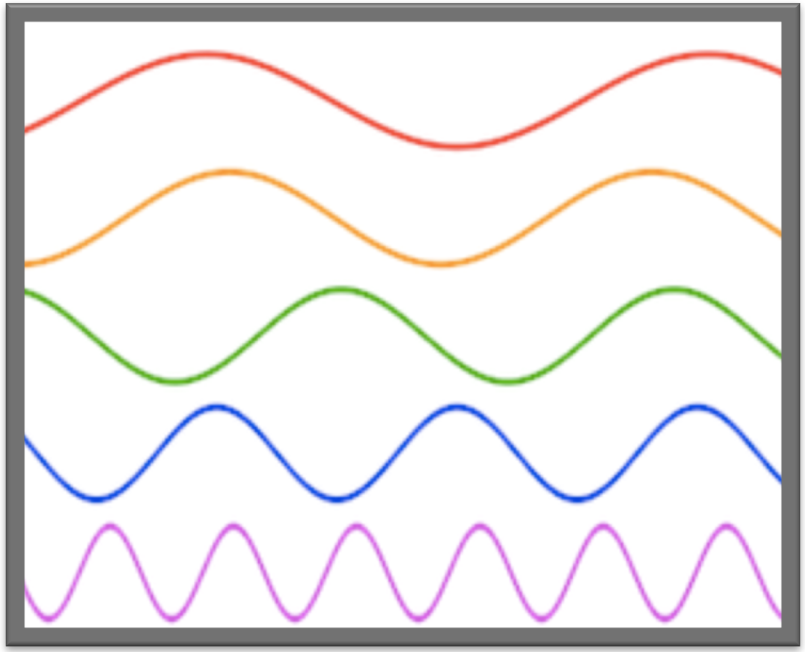
The Frequency Domain

- Time domain is values over time
- Frequency domain is amplitudes of component waves
- When observing a signal from this perspective we no longer ”see” time.
- Windowing our data and apply the Fourier Transform on each window allows us to generate cross sectional data
- Now we can preform more traditional ML tasks on signal data.



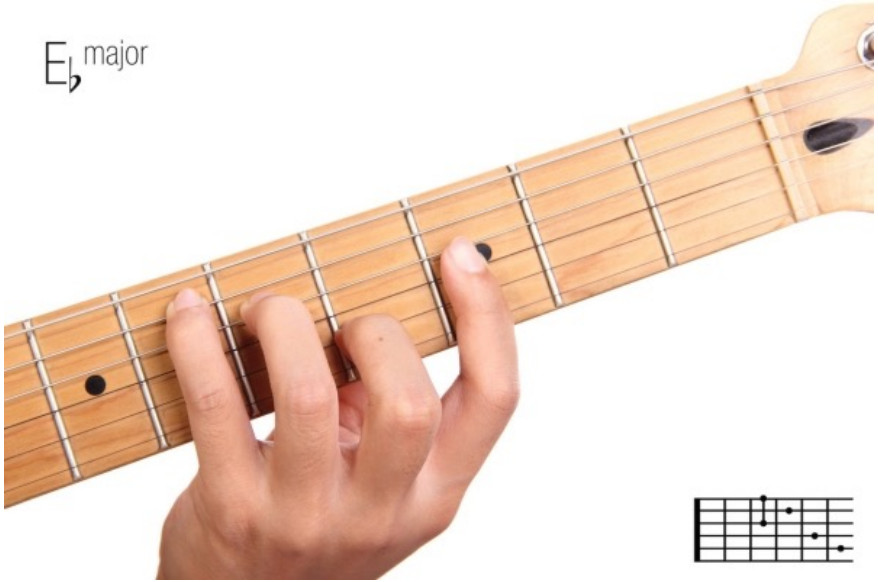
Window Functions

- When a wave is included cleanly in a window it corresponds stronger to the signal and is awarded a higher amplitude, sometimes unfairly.
- This is spectral leakage.
- Window functions smooth the ends of the windowed signal to zero to help compensate
- The Blackman Window function is considered a good general use function for audio data.



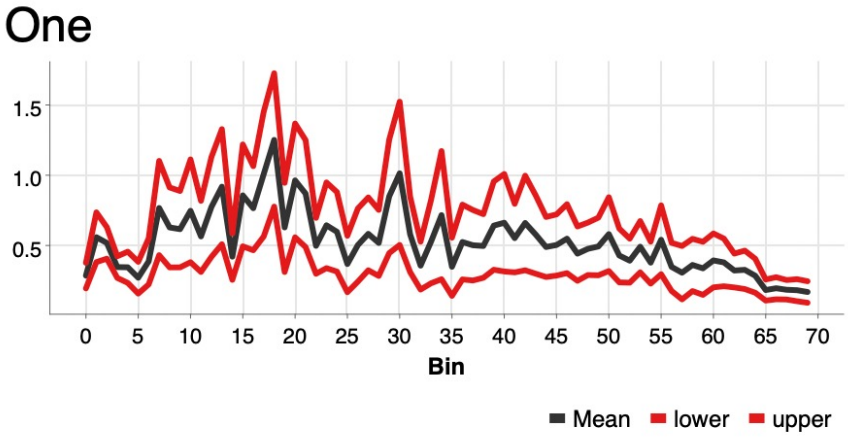
Why?

- Looking at data in the Frequency domain enables us to see otherwise hidden features
- Consider audio data, we can clearly extract primary notes played in music or even in voices.
- We can use this new dimension of clarity to watch for unusual components for anomaly detection
- Think new vibration patterns in machine maintenance.



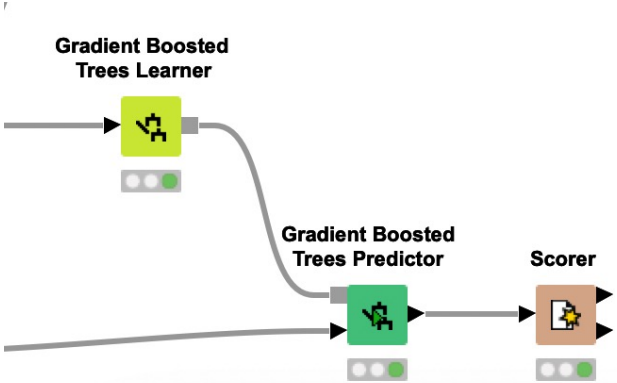
Reducing Dimensionality

- After Applying the Fourier Transform, we have many columns of data, the amplitude for each sine wave.
- Most dimensionality reduction techniques still apply here, but my favorite is binning.
- Since similar sine waves should have similar amplitudes, we can bin across our columns.



Modeling

- From her we perform familiar classification modeling
- We have numeric inputs
- Logistic regression are great here
- We had the best luck with a Gradient Boosted Forest



Confusion Matrix - 0:170 - Scorer

File Hilite

Prediction ...	one	four	three	two
one	251	18	14	5
four	4	243	2	1
three	3	1	211	11
two	5	1	36	246

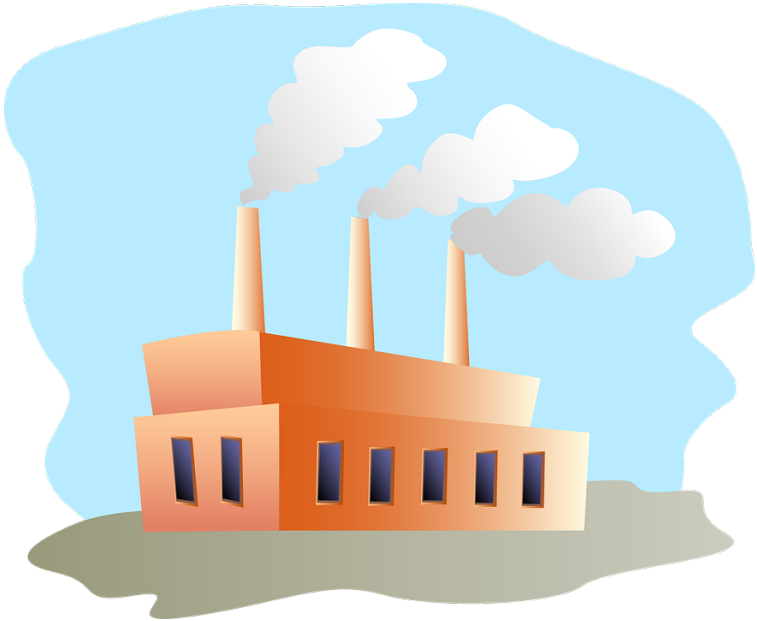
Correct classified: 951 Wrong classified: 101

Accuracy: 90.399% Error: 9.601%

Cohen's kappa (κ): 0.872%

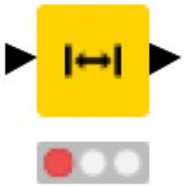
Where?

- The Fourier Transform is used in near every industry that collects time series or IoT data.
- Today we mostly talk about high frequency signal data, but it also has uses in low frequency time series for detecting repeating patterns.
- Data compression, anomaly detection, time series decomposition, signal cleaning, and more

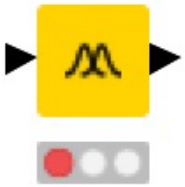


How?

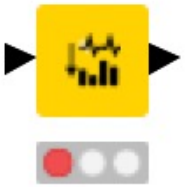
Window Slider



Window Function



Fast Fourier Transform (FFT)



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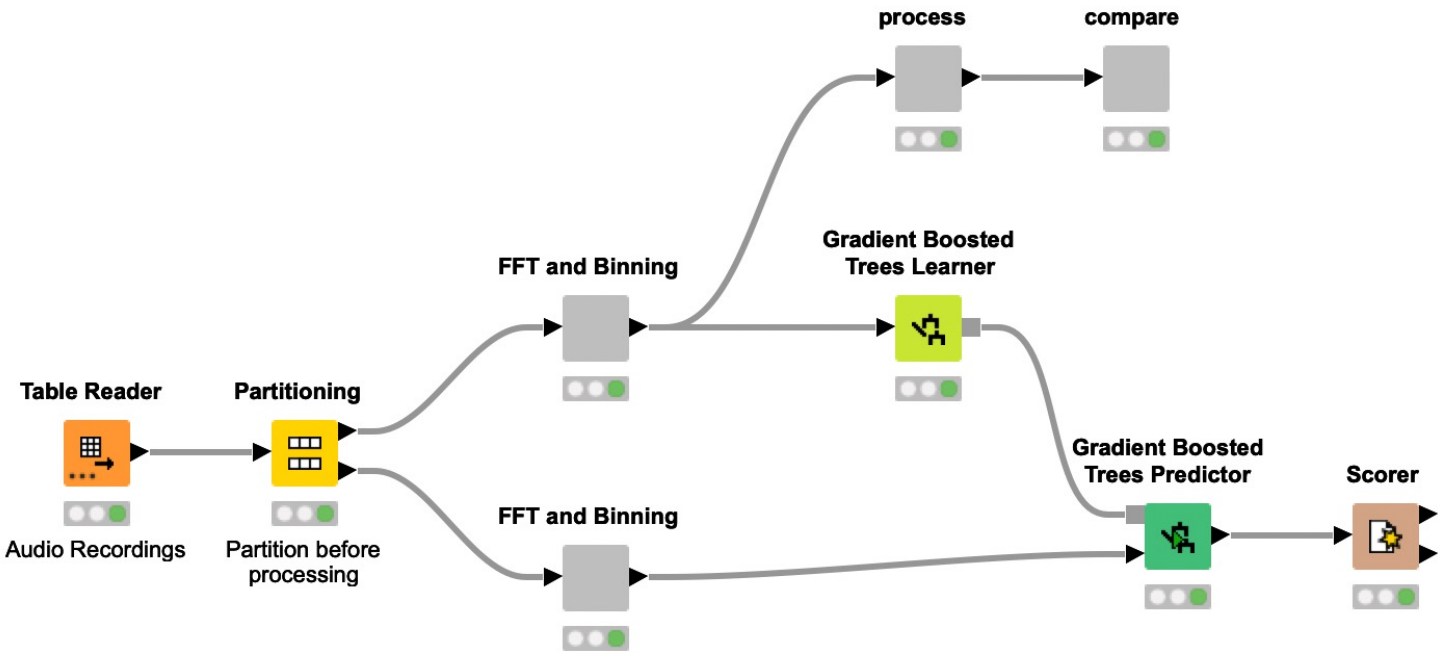
An Example in KNIME



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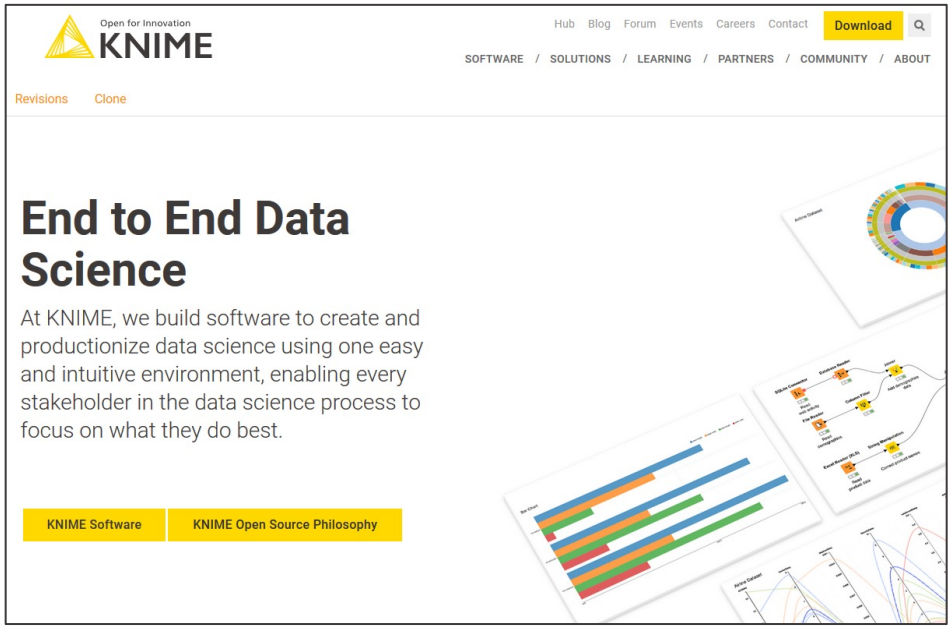

- ✓ Open source
- ✓ Free
- ✓ No restrictions
- ✓ No limitations

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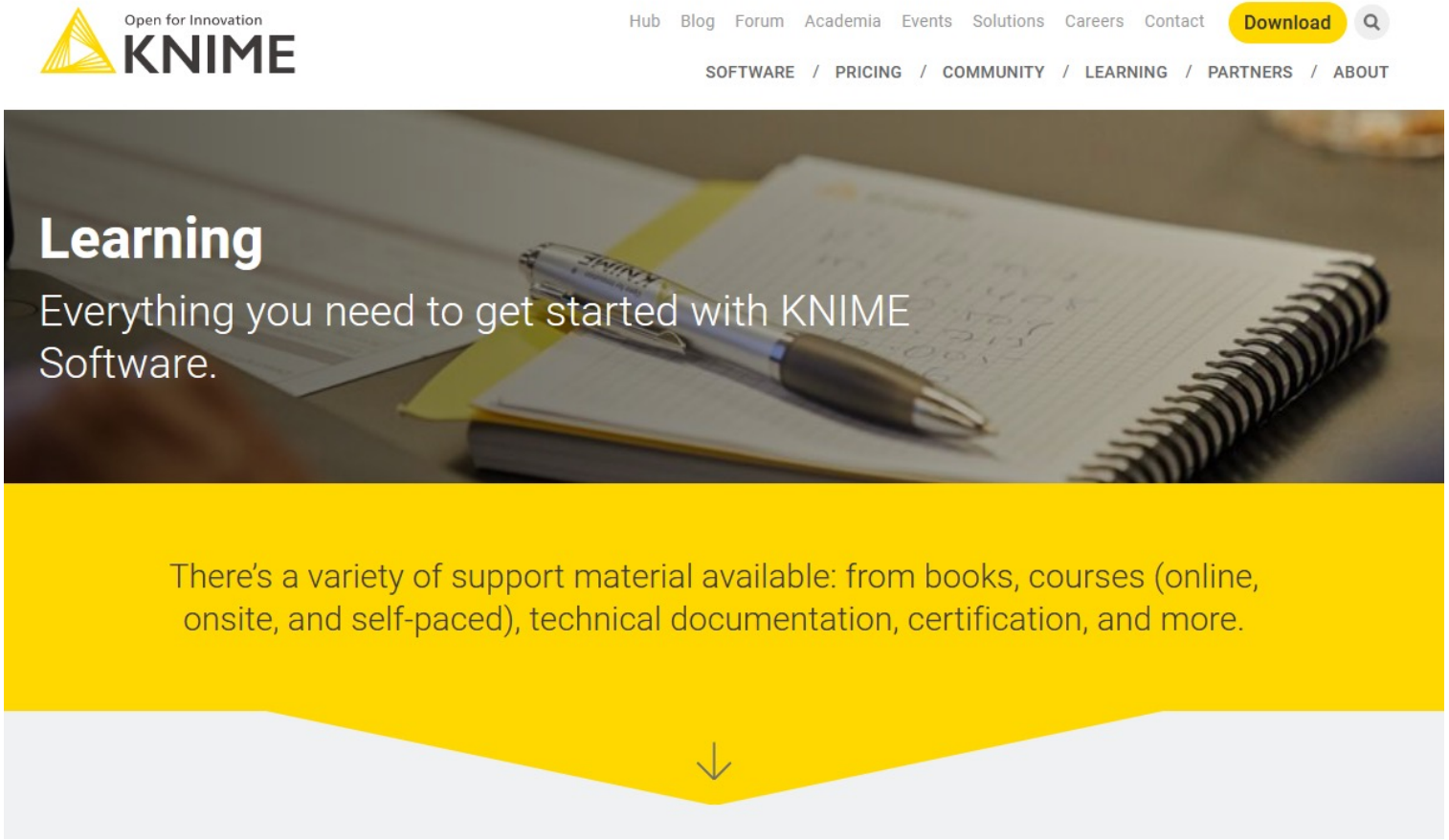
Learning Resources



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Questions?

1. Download: knime.com/downloads

2. Explore the Hub: hub.knime.com

3. Talk to us on the forum!
forum.knime.com

https://forum.knime.com/t/webinar-moving-into-the-frequency-domain-with-the-fourier-transform-march-17-2022/40312