

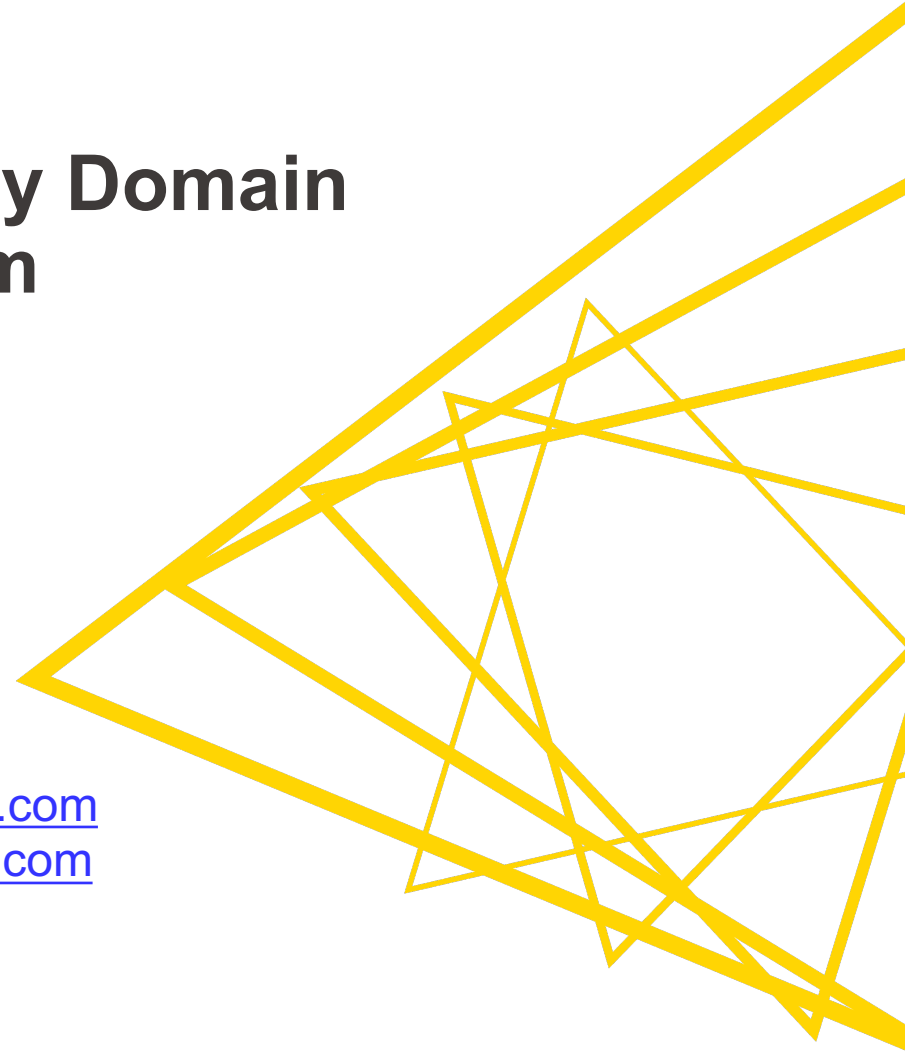
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KNIME

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.



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The Fourier Transform

$$x'_k = \sum_0^{N-1} x_k \cdot e^{-\frac{i2\pi}{N}kn}$$

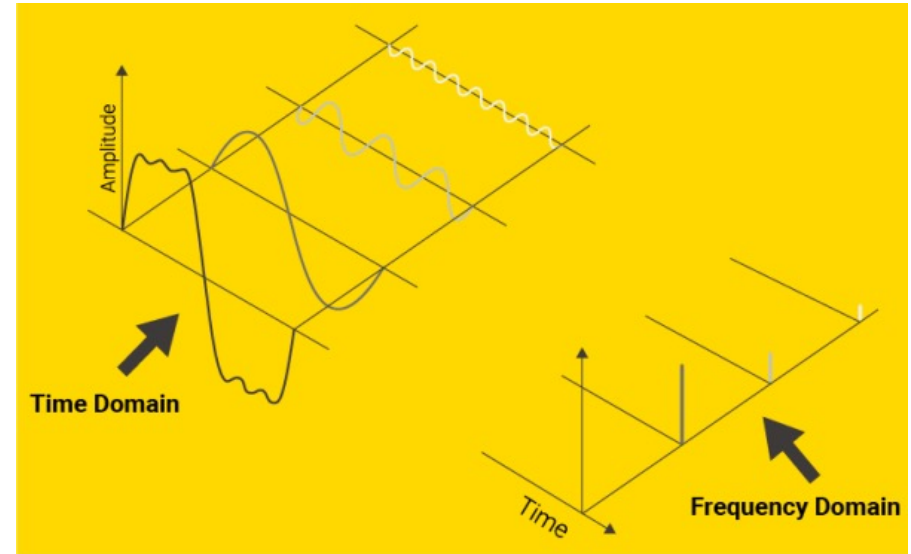
- Imagine we have many sine waves with varying frequencies.
- Then we take each wave and assign it an amplitude based on how strongly it corresponds(dot product) to our signal.
- Representing our raw signal as a sum of this sine waves is the Fourier Transform.
- When we look at these amplitudes, we're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



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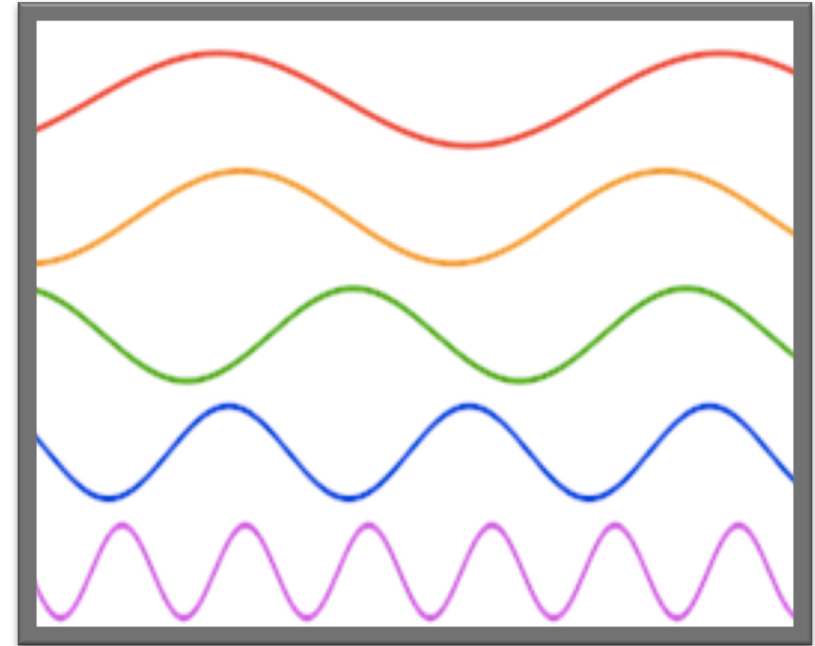
The Frequency Domain

- 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 perform 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.



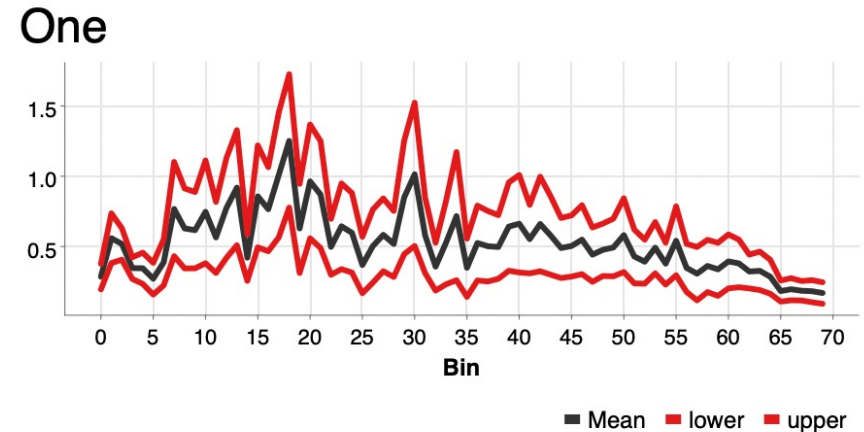
Why?

- 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.



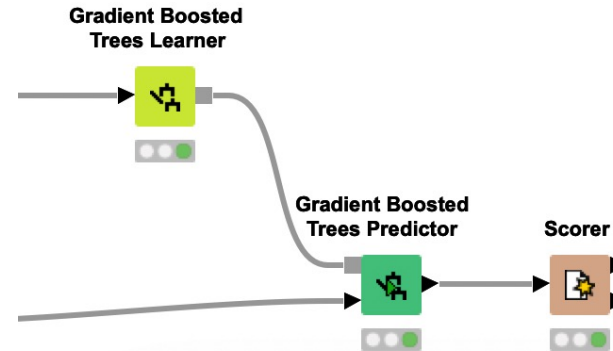
Reducing Dimensionality

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



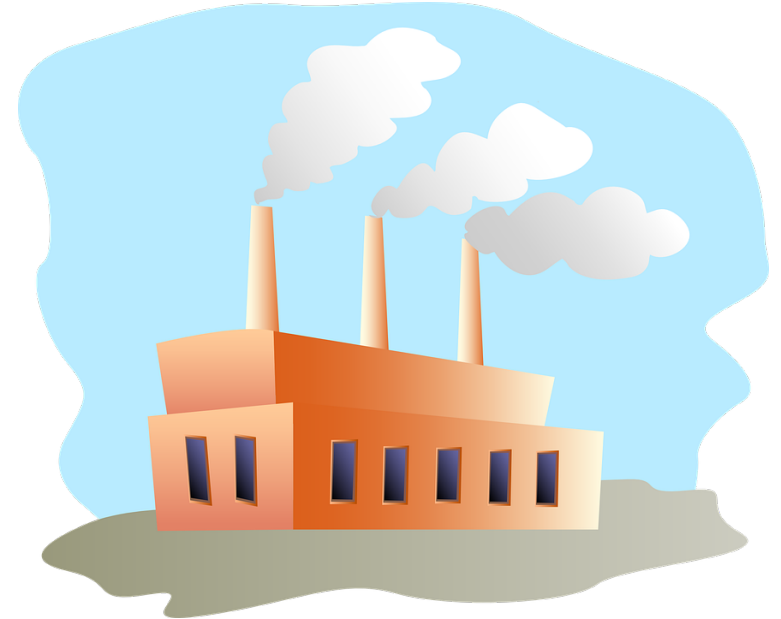
Confusion Matrix - 0:170 - Scorer

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%

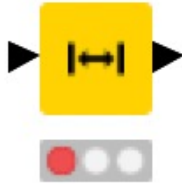
Where?

- 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

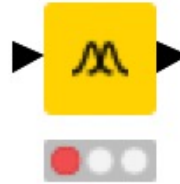


How?

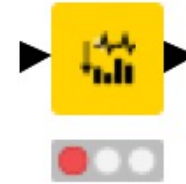
Window Slider



Window Function



Fast Fourier Transform (FFT)

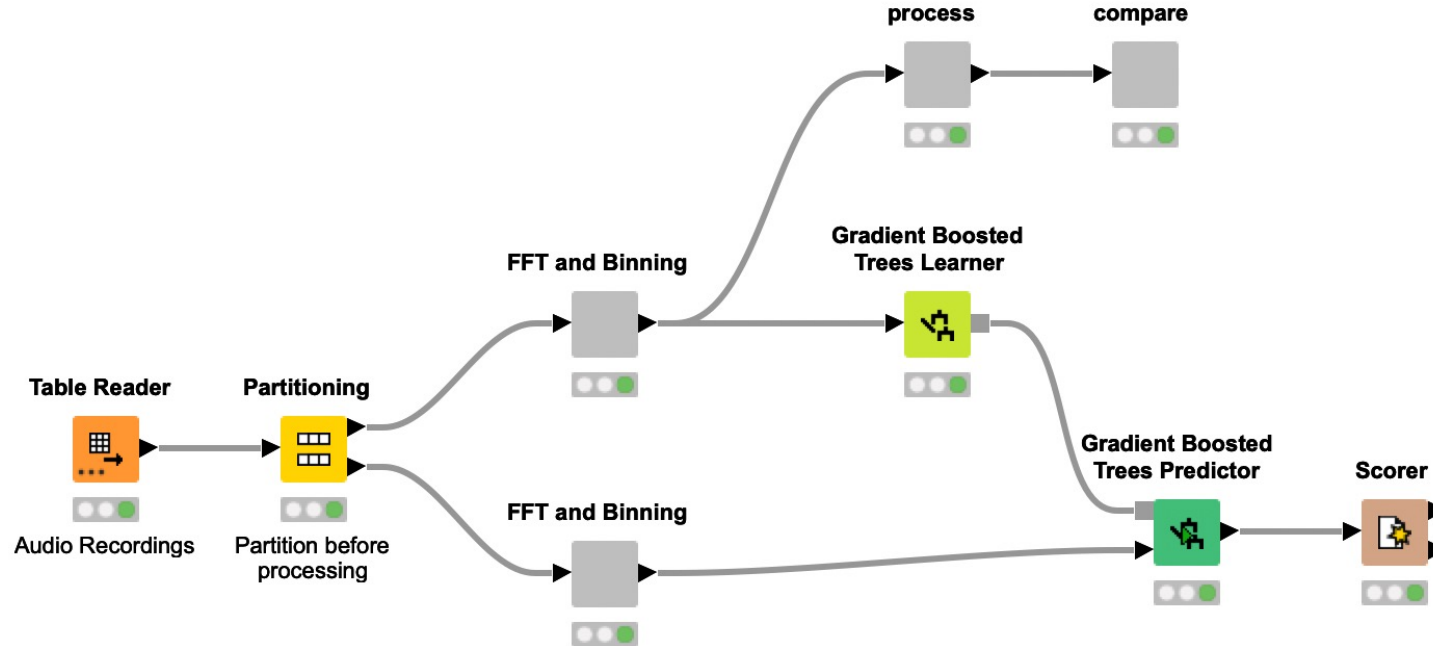


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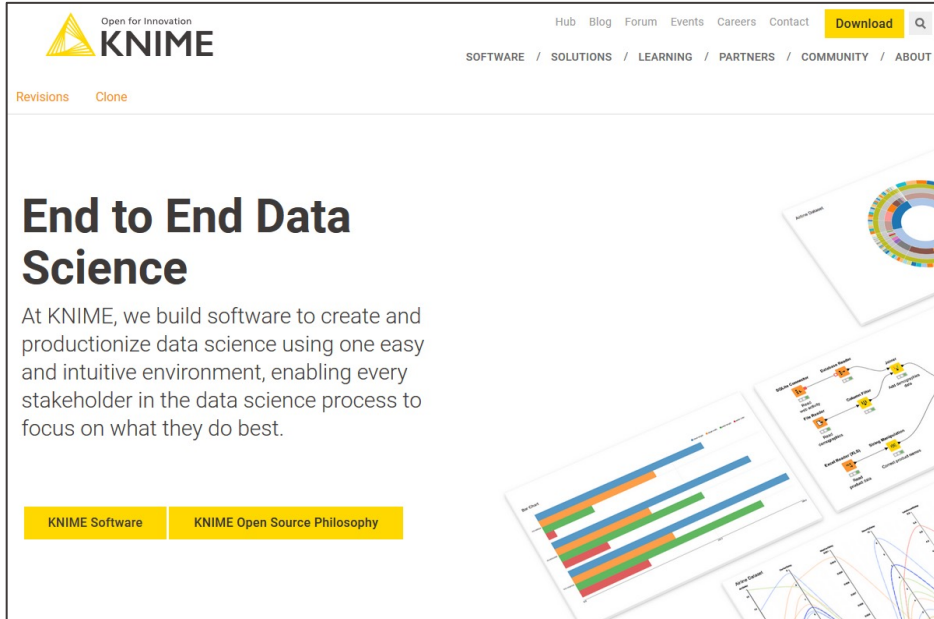
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An Example in KNIME



<https://kni.me/w/V3gkrNaVmC5Z14xo>

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A screenshot of the KNIME website homepage. The header features the KNIME logo with the tagline "Open for Innovation" and a navigation menu with links: Hub, Blog, Forum, Events, Careers, Contact, and a prominent yellow "Download" button. Below the header, there are links for "Revisions" and "Clone". The main content area has the heading "End to End Data Science" followed by a paragraph: "At KNIME, we build software to create and productionize data science using one easy and intuitive environment, enabling every stakeholder in the data science process to focus on what they do best." At the bottom of this section are two yellow buttons: "KNIME Software" and "KNIME Open Source Philosophy". The background of the main content area shows a collage of data science visualizations, including a circular chart, a bar chart, and a flow diagram.

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

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