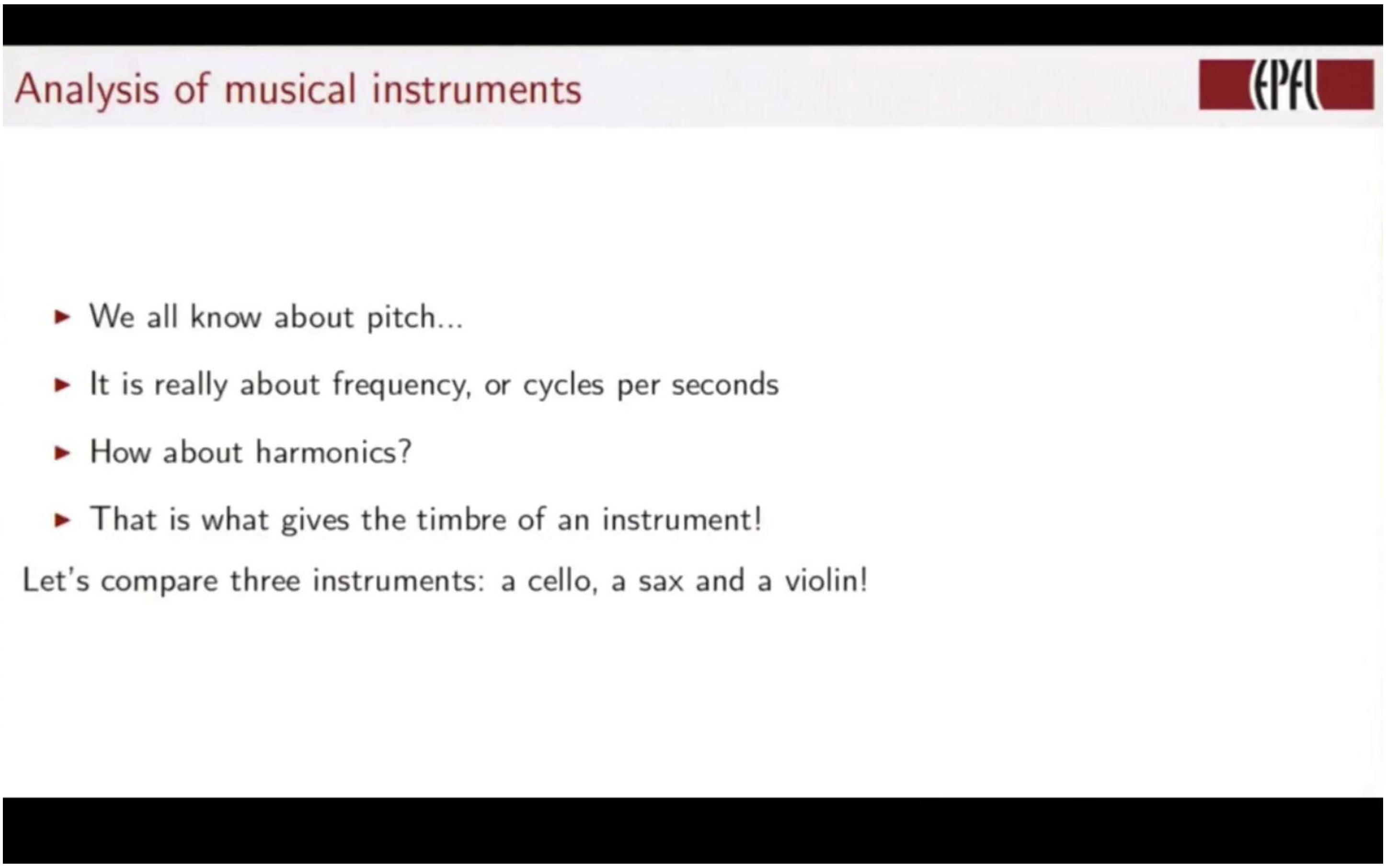

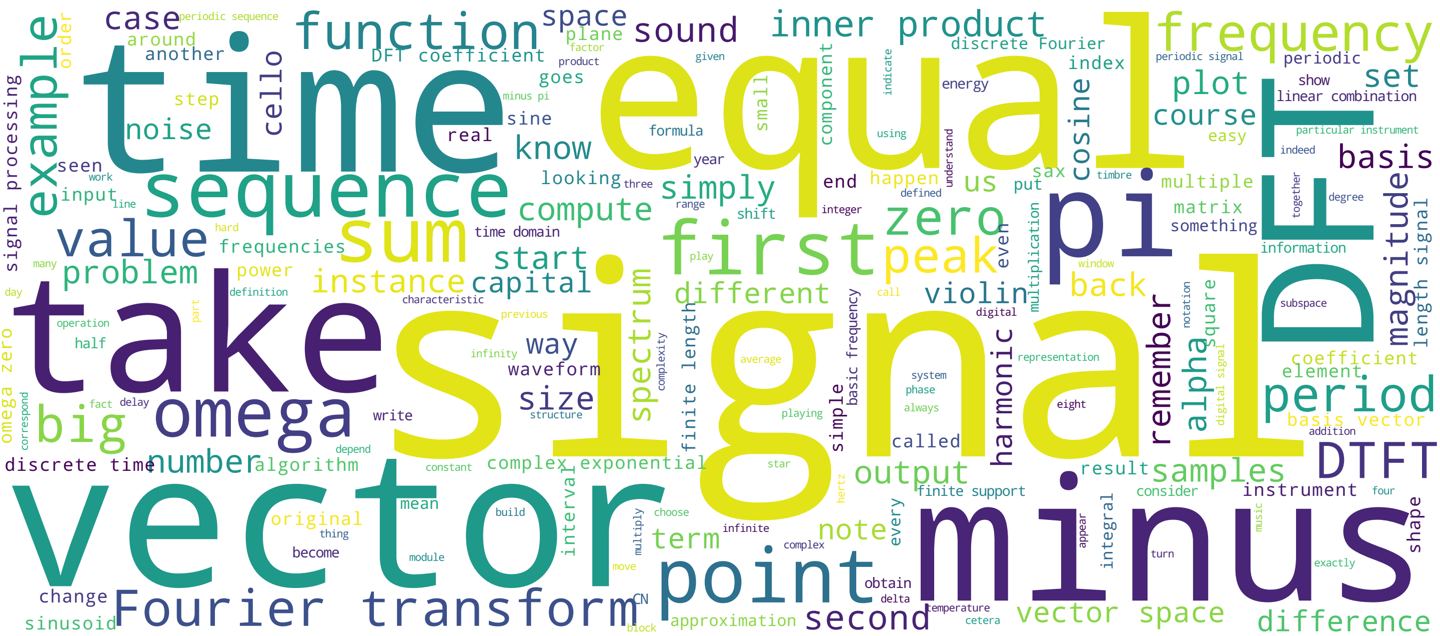

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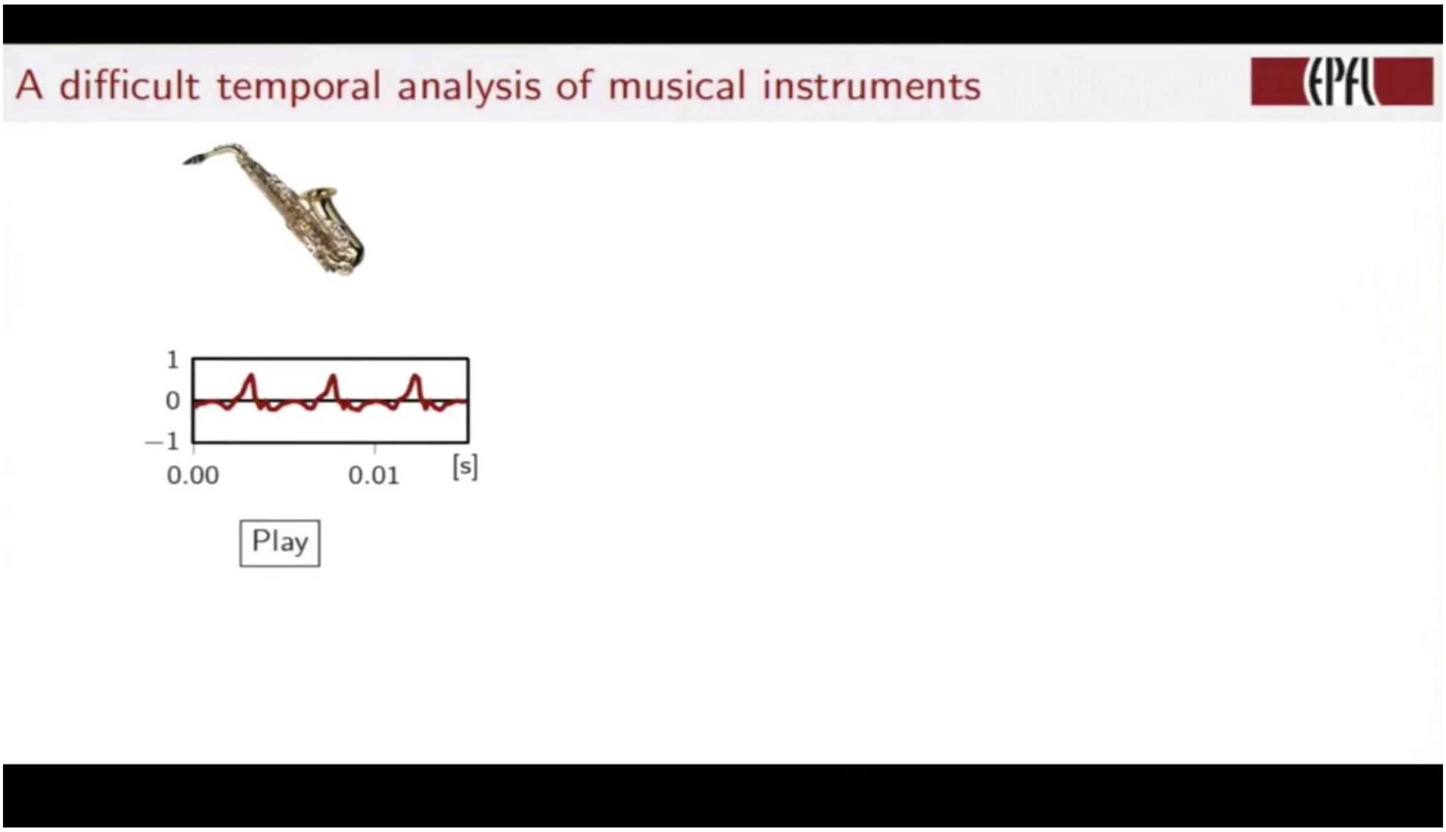
Video

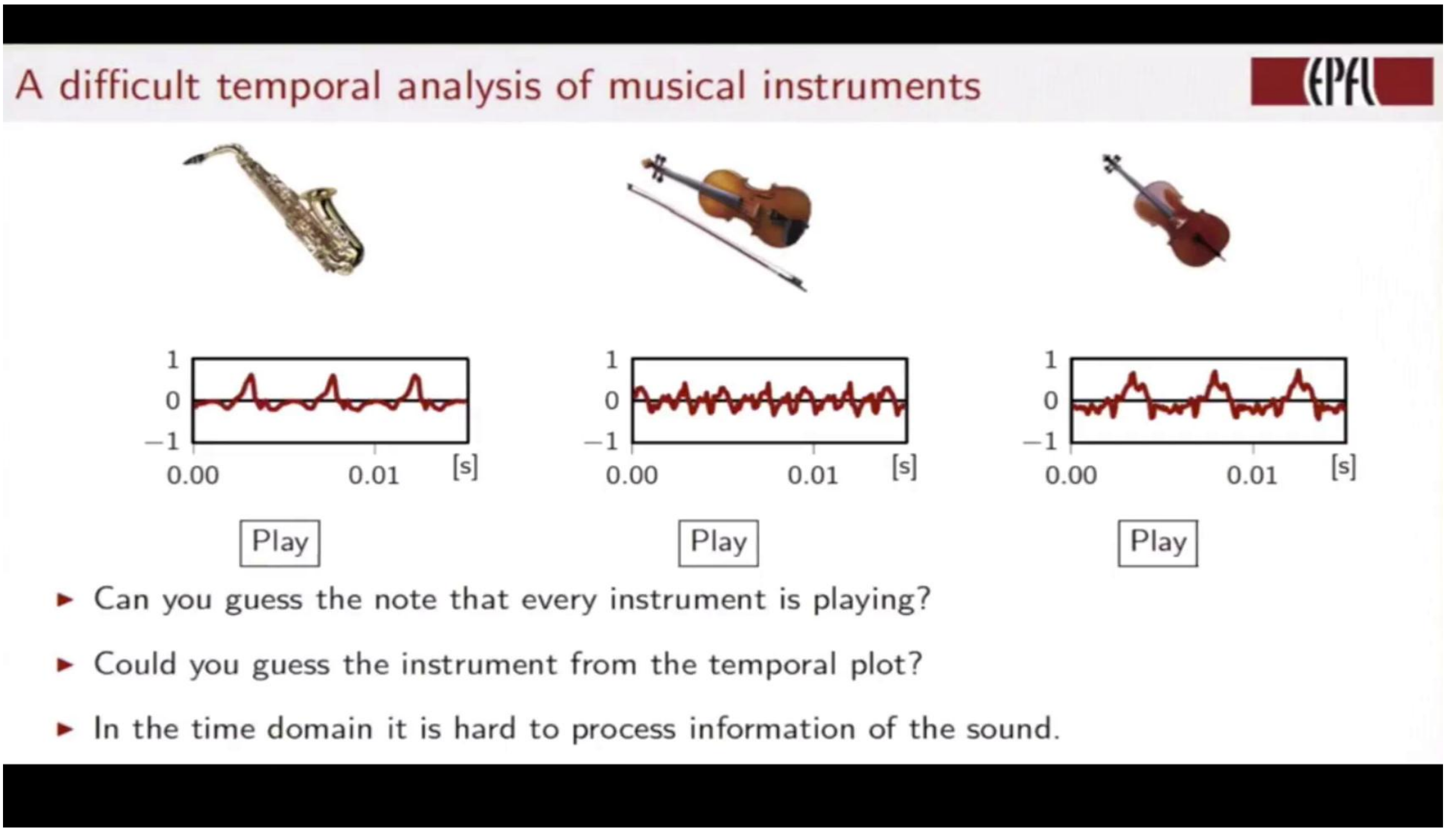


We all know about pitch, what is a basic frequency, for example, of a singing voice or a particular instrument playing a note. It is about frequency or cycles per second of the waveform. However, there is not only the basic frequency, there are all the harmonics. If the basic frequency is omega zero, you have two omega zero, three omega zero, four omega zero, et cetera, that the P are also typically in the sound and the shape of these harmonics, how big they are actually gives the timbre of the instrument. The characteristic of a particular sound. Let's compare three particular instruments a cello, a sax and a violin by looking at their Fourier spectra and understanding how the harmonics can look very different and give very different types of sounds. If you look at the waveform of a particular instrument, it is very hard to see how it's going to sound. We know this from, for example, the waveform of a speech signal, it's very hard to understand speech by looking at the waveform of the signal. So here the first case, we have a saxophone and we see a few periods of the basic sound. That's the sound pressure that is generated by the saxophone playing. Let us play this instrument.

Notes

Summary

0m 00s

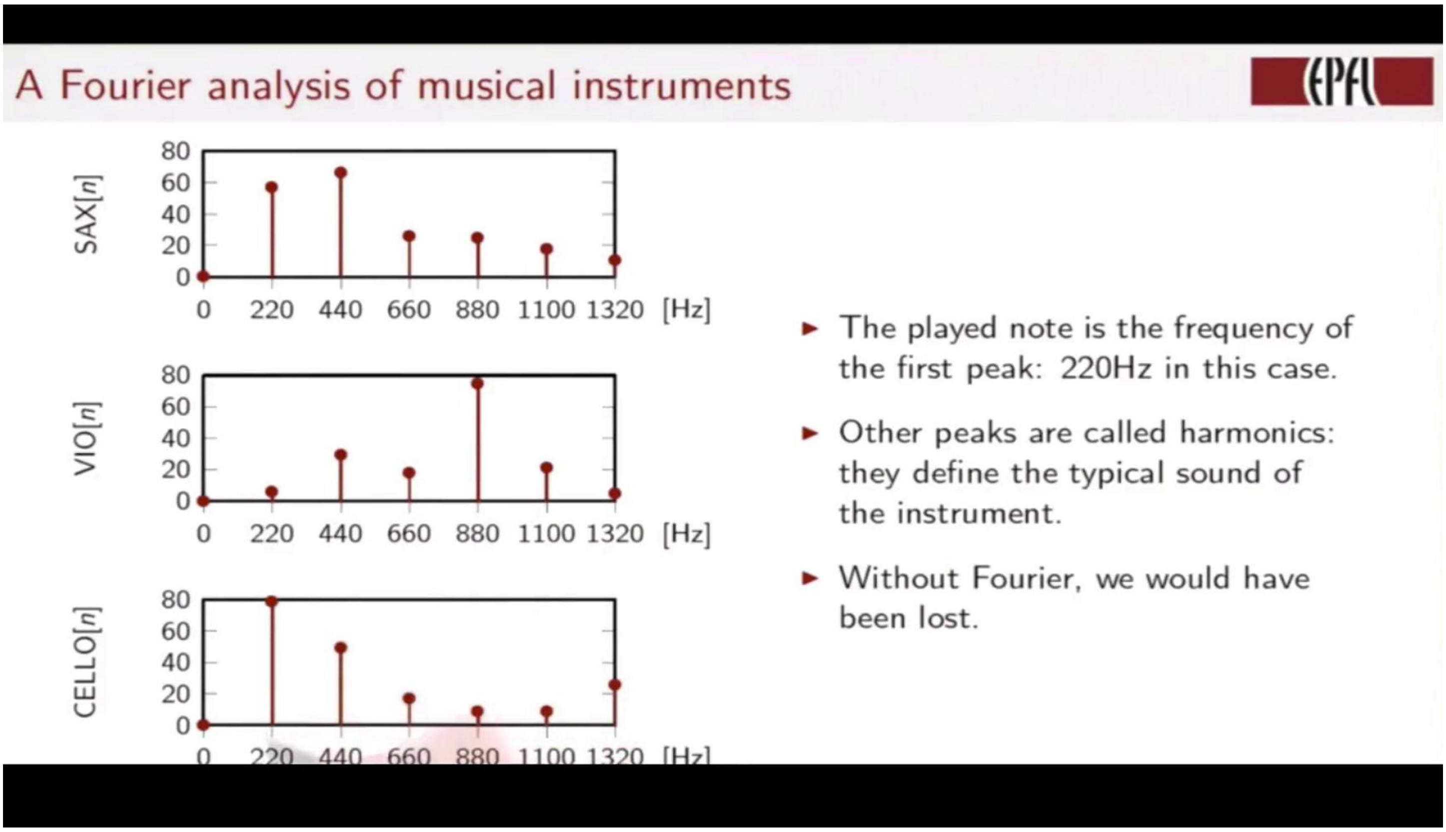


Now let's look at the very different instrument, namely a violin, again, we see a few periods of the sound that was recorded from a violin playing. It looks different, but we don't exactly know what is the difference going to be. So let's play this instrument. Let's look at a third instrument, a cello. The waveform looks different from the violin. So let us listen to it. Okay, now we have heard three different sounds. And if we were to play them back to you, can you guess what instrument is playing and what is the notes that the instrument is playing? That depends on your training, and many of you people can do this very well. But we are going to see a mathematical method to this, which is to take the Fourier transform or the discrete Fourier transform in this case, of a few periods of this signal. The message is, of course, that in time domain it is not easy to understand the signal. In full domain it will be much easier.

Notes

Summary

1m 28s



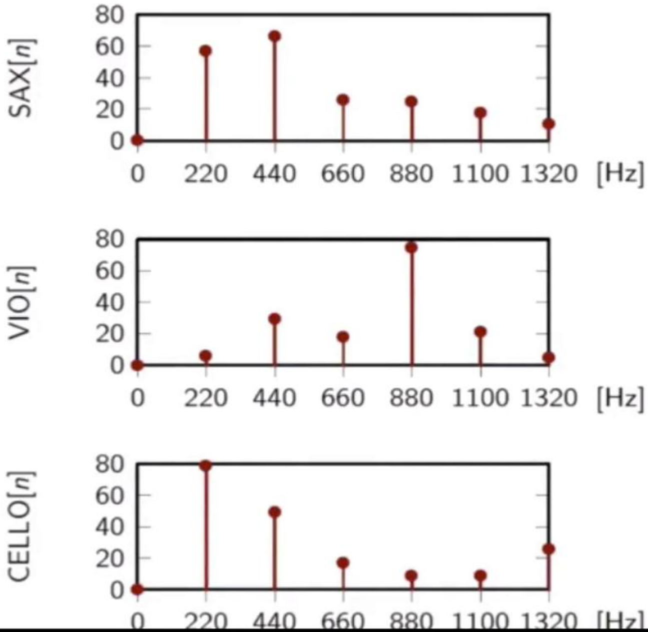
Here we plot the magnitude of the discrete Fourier transform coefficients taken from a few periods of these various signals. We plot them between zero and 1.32 kilohertz. On top you see is a sax. It has a few peaks, as you can see, a 220, 440, 660, et cetera. Then we have the violin. It has also a peak at 220, but a high peak at 880. At the bottom, the cello has also a peak at 220. Like the sax, it's a big one. Then 440 and then indication goes back up at 1320. You see the spectra look very different and definitely the violin looks very different from the cello and the sax. To some extent, the saxophone and the cello have somewhat of a similar sound. The warm, basic sound. And the violin is, as you can see from the peak at 880, has a more high frequency nature to it. The note is each time played at 220 hertz. The other peaks are what we call harmonics, and without using the Fourier transform, unless you're a trained musician, we might be lost. In some by looking at a Fourier spectrum, we can see that a fundamental note is a first peak in the spectrum. It's not necessarily the biggest peak, but it's the first one that appears. That's a note that is being played.

Notes

Summary

2m 42s

A Fourier analysis of musical instruments



- The played note is the frequency of the first peak: 220Hz in this case.
- Other peaks are called harmonics: they define the typical sound of the instrument.
- Without Fourier, we would have been lost.

The further peaks are the harmonics, and they are all multiples of the basic note, and the relative size of the harmonics gives a timbre or the characteristic of an instrument. Here we see in a very simple example, where the signal is periodic, that the discrete Fourier transform is very helpful in understanding these musical sounds.

Notes

Summary

4m 16s