[SQUEAKING]

[RUSTLING]

[CLICKING]

PROFESSOR: Hello, everybody, I want to explain a little bit on how we can visualize music using music21 or other tools, and how important it is to be able to see what is happening in a piece of music. Rather than going through a Jupyter Notebook, the *User's Guide to Music21* chapter 22, which there's a link pasted into the page that this is on, has a good introduction to some of the things that you can do with graphing and plotting.

We can go ahead and start by importing everything from music21. We really only need the corpus. And there's one piece by the Italian 19th century opera composer Giuseppe Verdi from his opera Rigoletto, called *La donna è mobile,* which we can load in using this corpus parse function and store it's variable verdi. Let's just look at the first 10 measures, and we can show it (SINGING) bum, bum, bum, bum, ba, dum, bum, bum, bum, ba, bum dum.

You probably may have heard this before. So this is a little piano-score version. And so let's just get the vocal part. And if we go ahead and call on this excerpt-- oh, by the way, I don't know if we fully explained, you can extract a measure range with these two numbers. This is inclusive, unlike Python, and so this will include measure 1 and measure 10. And these are the numbers according to how a musician would think of them.

We can go ahead and plot them. And by default, it creates something we usually call a piano roll because it kind of looks like how if you're going to punch the rolls outside of things like this. You can go ahead if you know matplotlib, or another plotting software, and create these things on your own, but there's a couple of things that music21 will take care of for you if I Zoom in. Oh, there it goes, oops. And some of them--

But there are some things that music21 will take care of for you. For instance, the pitch will have octave marks just on the C's or wherever something is. It will have correct flat signs or sharp signs and choose the right accidental for what's happening here. And things will be plotted by measure, even if the measures are difficult to deal with.

For instance, here's the little example where we use some pretty weird accidentals. The only C, really, is a D double flat, or so on. And it will put out-- you can barely see it, but it will put double flat there. And if your measures are different lengths, it'll do it. So it's probably a decent thing to go ahead and call the music21 plot if you want to visualize something.

We can load on another piece. This is Arnold Schoenberg, late 19th and early 20th-century composer from Austria, who is considered one of the creators of atonal music. And we'll load his piano piece, *Opus 19,* and we'll load movement two. This is just another way of loading a specific movement for a piece. And we'll excerpt measures 1 through 4 and show them.

There's a couple little problems here, but you can see this piece, a lot of (SINGING) bum, bum, bum, bum, bum, bums in it. And what we can do is, in the plot command, we can give it other things.

So we're going to do a scatter plot. We're going to map quarter length to pitch, and we'll give it a title. See the G and the B, and if we zoom in here, we can really see, oh, yeah, we're doing a scatter plot, and we're making it darker the more times things appear. And we can see the quarter length log 2. So they're equally spaced between 16th notes, eighth notes, quarter, and half note and see the various pitches here.

The other thing we can do is we can do a histogram of pitch of octaves. And we'll hide little ticks for anything that doesn't appear and put the number of pitches here. And we can really see these two, the G and the B, showing up a lot. Or we can just restrict it to specific pitch classes and see the pitch classes of G and B without the octaves still dominate on this piece.

You don't really need to install matplotlib anymore because it's now included with music21, but you will want, if you're using Jupyter Notebooks, to put this magic command at the beginning. And that will allow you to view everything in line.

You can go ahead and see what kinds of things are there, horizontal bars. We can plot, measure number and quarter length against the pitch, and so on. Various pitch histogram, scatter plots, counts of how often various pitch and note lengths appear.

We'll say how this happens later, but we can look at what the range of the piece is, How far apart it is in various places, or what the keys that are being detected in various parts of the piece using Carol Krumhansl-Schmuckler's key analyses. We can look at when various parts are playing, and I believe this is how loud they are.

Some silly 3D graphs which can be kind of helpful, maybe but maybe not. And it can also plot against dynamics, and you'll notice that it says mezzo forte, forte, forte piano, sforzando, fortissimo. So that there's built-in places for various dynamics. You can see what kinds of Atlas qualities there are, and so on.

So what we can do is we can look at how various composers, such as Robert Schumann, a mid-19th century composer, how he uses his pitches in a particular string quartet versus how Chopin uses his in one mazurka. Then always important to go back-- sorry, this is all distorted for the video ==and look at how the piece actually works.

In chapter 44, of the *music21 User's Guide,* completely optional, it'll tell you a little bit more on how you can customize plots with their title, change the size of the figures, change colors, and go ahead and make other plots highlight particular data, and remove data, substitute other things in there.

Not too much else, this is pretty advanced things going on. But we can look at offset versus cardinality. Well, you know what cardinality is now, how many pitches are sounding at once. Notice this little nice pickup measures at the beginning.

And maybe you want to plot how a frequency in Hertz goes against pitches but show white and black keys or in this case, red and black keys over time. And you can use this to make some various other graphs that might not come from data. These are all kind of interesting things. Smoothing out how Bach's motion works in a particular chorale.

There's a lot still to be done with plotting, but this is a great way to start. I'm also going to put in a link to Edward Tufte's, or Tufte, I'm not exactly sure, *Visual Display of Quantitative Information,* which is a book that has absolutely shaped how I think of what a good ways of creating graphs, why we want to create graphs, and how do we make the data stand out and still be beautiful.

Thanks a lot for listening and hope to see some beautiful graphs in the future.