Rates of Change Theory transcript

Life and science are about change. So far, we've plotted graphs that reflect the data values. Now let's generate and plot data that looks at the relationships within the data set.

The simplest one is how much the data changes from one value to the next.

This is called a rate of change and is important in many aspects of our lives.

(few seconds quiet). We know this doesn't happen, for a variety of reasons, but knowing the expected rates of change are important. How do we do this? Is there a way to quantify and visualize this?

Yes, there is.

First, how do you do it? Let's attempt to quantify bacterial growth using a small data set called size.

Here is the data. To determine the change from day 1 to day21, we subtract day 1 from day 2, and get a 3. To determine the change from Day 4 to Day 5, we do the same – subtract Day 4 from Day 5 and get 2 – this is not the same, so the rate slowed down. Using the same procedures, let's generate the rest of the values. Notice that the rate goes up for the 2nd day and then decreases for the rest of the data set. As scientists, we can analyze this rate change to determine the cause, but overall, the rate of change is the difference from one point to the next.

Now that we can do this by hand, how do we get MATLAB to do it for us? We have the skills right now for this small data set, but I would not want to do this for a much larger data set!

How do we get MATLAB to do it for us? As the rate of change is the difference, the function to calculate this is diff.

The syntax for this function is fairly straight forward, assuming you have a vector and want to find the difference from one value to the next. In our bacterial measurements, we started with 7 values, and, after finding the diff, had 6 values to work with – this is because finding the difference calculates the relationship between values and so your results are always one less in size.

Unfortunately, many of our data sets are more complicated than vectors, and so we need to be able to do this same function on a multi dimensional array, and find more than the simple difference. MATLAB will do that for us if we know the syntax, using the diff function.

Like all MATLAB functions, the default is the first dimension, so if you want to find the difference down, there is no change. But if your data is structured differently, then the diff function syntax is similar to min and max in that the dimension is the third argument, and must be addressed.

The second argument is the number of times you want to do this, and the default is one – you only find the difference one time. If you want to do find the difference multiple times, then you can change the second argument.

The third argument is the dimension, so if you want to find the difference along the 2^{nd} dimension, you must put in the 2^{nd} argument.

Let's look at an example going in the first dimension.

Given the array x, shown here. Here is the command we're giving MATLAB. It is the equivalent of diff(x) but all the arguments are given. The second argument is a one, which means we're only doing it once, and the third argument is a one, which means finding the difference on the first dimension, which is finding the difference between the rows.

The values can be found by subtracting the first row from the 2^{nd} row – which is 1-2 for the first column, 3-6 for the second and so on. Notice that we started with 3 rows, and end up with 2.

Now to do this on the second dimension, starting with the same x, here is the command to create the variable. Notice the 3^{rd} argument is a 2, which means second dimension, going across.

To get these values, subtract the first row from the second, which is 6-2, 4-6 and 5-4. Again, notice that you will end up with 3 columns, when you started with 4.

If you've been paying attention, this is the slope of the line through the points on the equation, and the concept of slope brings all sorts of other options, such as positive, negative, infinite and zero that you can use in your analysis. For a line, this is straight forward, but much of science is not straight and cannot be modeled linearly, so you have a polynomial describing your system, and so you must look at maxima, minima and transition points.