

MUS 470/470L Homework 2

Fall 2020

Due date: Thursday, October 8.

1. Implement the first four real spherical harmonic functions in code.
2. Graph a linear combination of these using any 3D graphing software API.
3. Illustrate the basic microphone directivity patterns using this graphing software by selecting coefficients of the linear combination in the previous part.
4. Design a simple UI which allows the user to change the coefficients of the four functions, and also has presets for examples of the directivity patterns in the previous part.

Just to be sure we are all on the same page, here are formulas for the real spherical harmonic functions up to order one, using the formulas from Wikipedia page 7, section 4.3:

$$y_{0,0} = \frac{1}{2} \frac{1}{\sqrt{2\pi}}$$

$$y_{1,-1} = \frac{1}{2} \sqrt{\frac{3}{\pi}} \sin \theta \sin \phi$$

$$y_{1,0} = \frac{1}{2} \sqrt{\frac{3}{\pi}} \cos \theta$$

$$y_{1,1} = \frac{1}{2} \sqrt{\frac{3}{\pi}} \sin \theta \cos \phi$$

As explained in Wikipedia page 3, section 2, the angle θ is *colatitude* measuring 0 at the north pole, $\pi/2$ at the equator, and π at the south pole. The angle ϕ is *longitude* or *azimuth*, measuring angles $0 \leq \phi < 2\pi$ starting from the positive x -axis.

Each function computes a real output given two angular inputs. This produces a point in spherical coordinates where the output is interpreted as radius ρ . When the radius is negative, it is traditional to graph the output values with a different color but positive radius. This also corresponds to the negative polarity in the microphone pattern. When functions are added, however, the negative is taken into account.

Refer to the microphone patterns in the article below, using all but the last one, which is the lobar pattern or shotgun mic. This last one needs higher order spherical harmonics, and you can do this one for extra credit, but it is optional.

References:

1. *Wikipedia*: https://en.wikipedia.org/wiki/Spherical_harmonics [click here](#)
2. *Microphone Geeks*: <http://microphonegeeks.com/different-microphone-polar-patterns/> [click here](#)