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Audio modification competition

As you might know, we can distinguish in which direction a sound comes from. Our brain does this by taking into account what each ear has perceived. In a stereo sound, a different track is played for each ear. If we modify these audio tracks to mimic how our brain interprets the direction of the sound, we can create the illusion of a moving audio source. With this purpose, the following function has been developed:

```
function [VAc] = audio8D(VA, Fs, w)
   x = linspace(0,length(VA)/Fs*w,length(VA));
   A1=cos(x+pi)+1+0.5*sin(x);
   A2=cos(x)+1+0.5*sin(x);
   s=size(VA);
   VAc=zeros(s(1),2);
   r = Fs*0.000133;
   for n=1:length(VA)
       VAc(n,1)=max(-1,min(1,A1(n)*VA(max(1,min(length(VA),n-round(cos(x(n)+pi)*r))),1)));
       VAc(n,2)=max(-1,min(1,A2(n)*VA(max(1,min(length(VA),n-round(cos(x(n))*r))),s(2))));
   end
end
```

In the following pages, the way the function works will be discussed.

There are three main phenomena that our brain uses to know the location of an audio source, which are the following:

- Amplitude
- Delay
- Frequency

As the function was limited to 15 lines and to try to reduce complexity, we will focus in the first two. Nevertheless, in future versions of the program, algorithms implementing the Doppler effect and other functionalities concerning frequency could be added to make the program even more realistic.

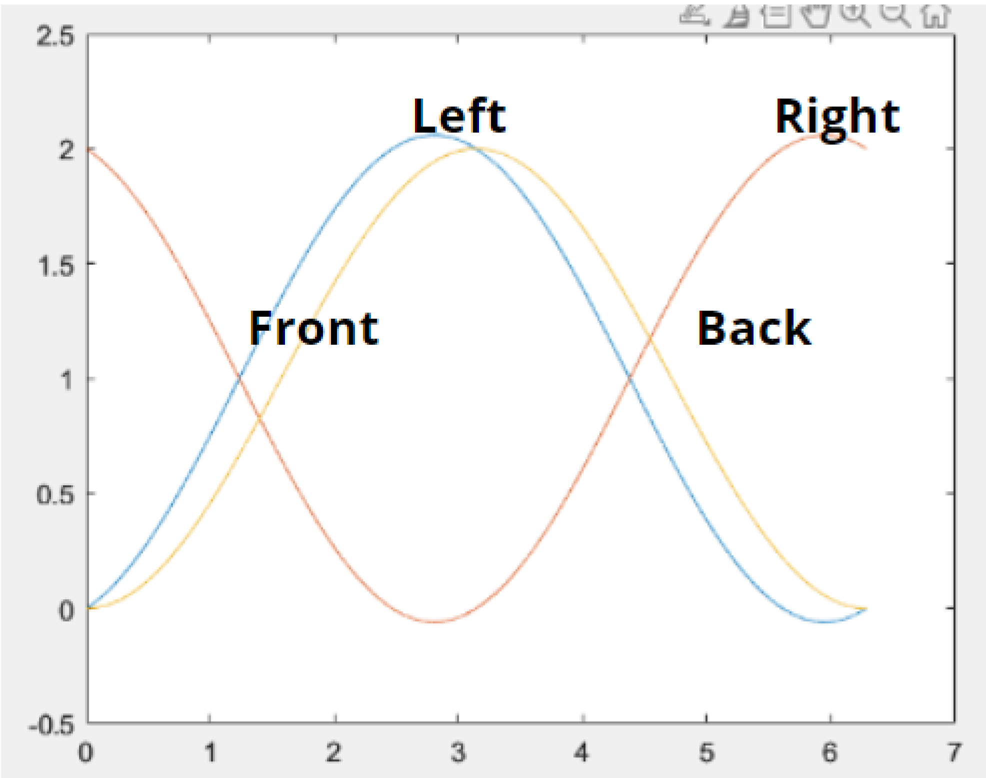
Amplitude

If sound comes from the right, it would be heard higher in that ear as the other will have the head blocking part of the wave. For this reason, the amplitude of each ear is multiplied by a scalar that will modify its value. A cosine function was chosen to make these scalars over time for transitions to be smooth. Each ear has a difference in phase of π radians.

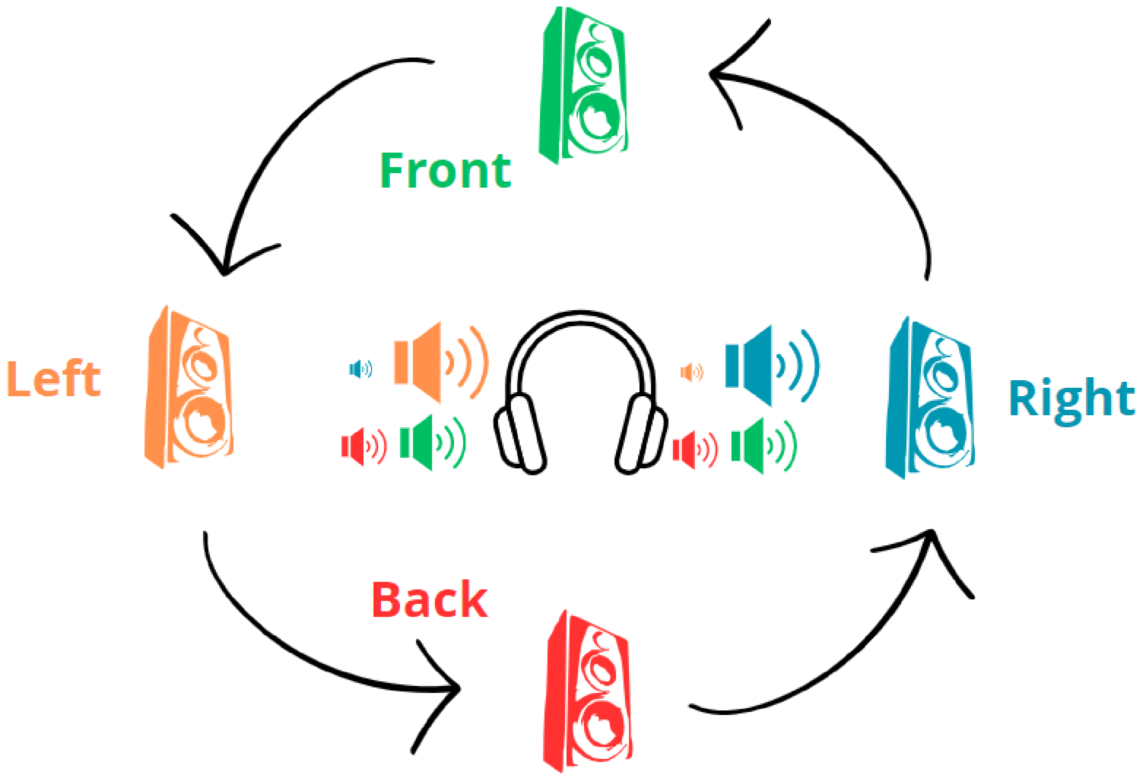
If the sound comes from behind, the back part of the ear will block part of the sound, which would be equal in both ears if the source is centered. For this reason, the same sine function is added to both.

In the following graph, it can be seen the result of these transformations. The blue line is for the left ear and the orange for the right one. It can be seen that when one increases, the other decreases being equal when the source is in front or behind.

The yellow signal is just the cosine of the left ear without the sine added. It can be noted when compared to the blue one that the blue one fulfills being higher when sound is supposed to come from in front and lower when it comes from the back.



The following drawing clarifies the different situations reproduced by the program.

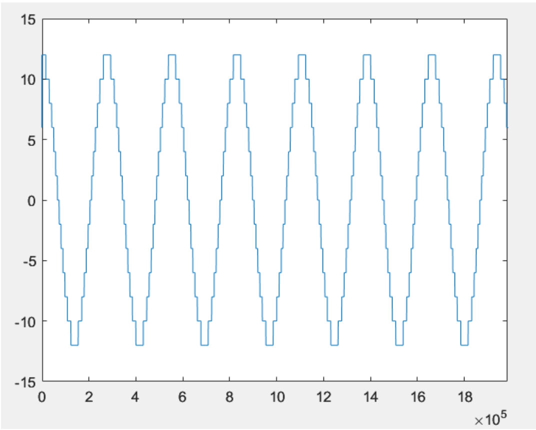


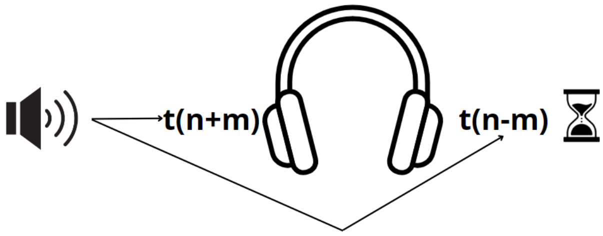
Delay

If one sound comes from the right, it will be heard first in the right ear and then on the left, as it has to travel a longer distance. To simulate this, first how long it will take for sound to go through a human head has been calculated. It has been assumed that sound travels through human body at the same speed as in water and that an average head measures 20 cm.

$$t = \frac{D_{head}}{v_{sound}} = \frac{0.2\ m}{1500\ m/s} = 0.000133\ s$$

In contrast with the amplitude modulation, this effect depends on discrete values in which time is divided. This makes it more challenging as the delay must be rounded to positive integers values. The final result uses two cosine functions with a difference in phase of π radians again. In the Y-axis we have the value of m that changes from positive to negative each half turn. The X-axis stands for n, which are the samples in which sound is divided. As can be seen, one ear perceives sound earlier when the sound is at that side and later when the source travels to the other side.





The program works both for already stereo sound introducing the effect, or for mono transforming it to stereo and adding the effect. The period of the turns can be controlled with the variable *w,* which stands for the angular frequency.