# Overview

This code simulates the process of determining the position of a sound source in a 3D space. Microphones, the actual sound source, and ambient noise sources are located at specific positions. The sound levels (in decibels) measured at the microphones are a combination of signals from both the actual sound source and ambient noise sources. The aim is to estimate the position of the actual sound source by using these decibel values measured at the microphones.

## Processing Steps:

### 1. Distance Calculations

Function: calculate\_distance(mic\_pos, source\_pos)  
  
Purpose: Calculate the Euclidean distance between the microphone and the sound source.  
  
Formula:  
  
Distance = sqrt((x\_mic - x\_source)^2 + (y\_mic - y\_source)^2 + (z\_mic - z\_source)^2)  
  
Explanation: The positions of the microphones and sound sources are given as 3D coordinates. This calculation is required to determine how much the sound attenuates as it reaches the microphones.

### 2. Decibel (dB) Calculations

Function: calculate\_db(distance, source\_db)  
  
Purpose: Calculate the decibel level at the microphone based on the distance from the sound source.  
  
Formula:  
  
dB = Source dB - 20 x log10(Distance)  
  
Explanation: Sound waves lose energy as the distance increases. This formula expresses how the sound from a point source weakens with distance.

### 3. Total Power and Total Decibel Calculations

Explanation: The total decibel level measured at the microphones is a combination of sounds from all sources (both the real source and noise sources).  
  
Steps:  
  
Power from each source is calculated and converted to total power.  
  
Formula: Power = 10^(dB/10)  
  
Total power is then converted back to decibels:  
  
Total dB = 10 x log10(Total Power)

### 4. Localization of the Sound Source using Optimization

Function: perform\_localization()  
  
Purpose: Estimate the position of the sound source using the decibel values measured at the microphones.  
  
Method: The objective function minimizes the total error between measured and estimated decibel values.  
  
Steps:  
  
The error between measured and estimated decibel values is calculated.  
  
The optimization algorithm minimizes this using the BFGS method.

## Code Flow and Calculations:

1. Initially: Microphones and noise sources are placed at random positions.  
  
2. When a Sound Source is Added: The perform\_localization() function runs, calculating the total decibel values measured at the microphones.  
  
3. Optimization: The position that minimizes the total error between measured and estimated decibel values is found.  
  
4. Visualization of Results: The estimated source position is shown on the graph.

## Conclusion

These mathematical models are essential for accurately estimating the position of a sound source. By combining physical principles with optimization techniques, we solve a complex problem:  
  
Distance and Decibel Calculations model sound attenuation with distance.  
  
Power Summations correctly combine sounds from multiple sources.  
  
The Optimization Algorithm finds the most accurate source position by minimizing the difference between measured and estimated data.