KSIM

Acoustoelectric Simulator

*EUNIL*

Table of Contents

[KSIM Functionalities 3](#_Toc117110000)

[GUI Overview 4](#_Toc117110001)

[How to run a full 2D acoustoelectric simulation 5](#_Toc117110002)

[Creating a simulation grid (kgrid) 6](#_Toc117110003)

[Creating a medium 7](#_Toc117110004)

[Creating sensors 8](#_Toc117110005)

[Creating an acoustic transducer 9](#_Toc117110006)

[Running and acoustic simulation 10](#_Toc117110007)

[Creating currents sources 11](#_Toc117110008)

[Running an acoustoelectric simulation 12](#_Toc117110009)

[Analyzing the results 13](#_Toc117110010)

[Running a full 3D acoustoelectric Simulation 14](#_Toc117110011)

[Load CT 15](#_Toc117110012)

[Electroids 16](#_Toc117110013)

[Automated functions 17](#_Toc117110014)

[Aberration Correction 18](#_Toc117110015)

[Analytical corrections 19](#_Toc117110016)

[Time Reversal 20](#_Toc117110017)

[adding noise 21](#_Toc117110018)

[Basic Analysis 22](#_Toc117110019)

# KSIM Functionalities

* Conduct 2D and 3D acoustic simulations
* Use heterogenous media
* Record 2D (plane) or 3D (volume) acoustic data
* Utilize independent acoustic sources
* Construct 2D and 3D acoustic arrays (simulated transducers)
* Perform focused, plane wave, or Hadamard encoded transmits
* Perform multiple transmits in a single simulation
* Display and analyze metrics from recorded images/movies
* Save simulations
* Create and save external figures
* Perform AE time-reversal simulations
* Create rudimentary current sources
* Perform acoustoelectric scans and reconstructions
* Implement lead fields for AE scans
* Export to beautify for full analysis

# GUI Overview

Graphical user interface

Description automatically generated

The GUI is broken up into different sections that all contribute to a single simulation. Each section is highly modifiable. Built in displays and analysis tools are provided, but exportation to separate software is also viable (and usually preferable).

# How to run a full 2D acoustoelectric simulation

The following steps involved are typically as follows:

1. Create kgrid
2. Create medium
3. Create sensors
4. Create transducer
5. Run acoustic simulation
6. Create current sources
7. Run AE simulation
8. View in ksim or beautify

## Creating a simulation grid (kgrid)

The *kgrid* structure in matlab contains all of the variables associated with the spatiotemporal domain of the simulation such has number of dimensions, pixels and time points along with their sizes. Note that this does not include anything to do with the medium properties of each pixel (that is set in the [**medium**](#_Creating_a_medium)section).

The eight boxes of this panel design the simulation space. They are**: Nx, Ny, Nz, Nt, dx, dy, dz,** and **dt.** The boxes labeled with “N” dictate the number of pixels (or timepoint) of their dimensions. The boxes labeled with “d” dictate the size of each unit for their associated dimensions. Note that spatial dimensions are in millimeters and the time dimension is in microseconds. For example, an Nx of 100 and dx of 0.1 will give an X dimension of 10mm.

By definition in kwave (and KSIM but association), a 2D simulation will use the X and Y dimensions only. In order to do this, set Nz to 0 when making the grid. For a 2D simulation, X will determine the azimuthal (lateral) dimension, whereas Y represents depth. If Z is included, the simulation becomes 3D where Z is elevational and where Y becomes azimuthal and X becomes depth.

After setting parameters, press **Make Grid** to create or update the *kgrid* variable in the workspace.

The **Viewer** button in this section is not used for making a kgrid. Instead it is a link to open beautify.

When creating a kgrid, make sure to input sane parameters. For example, don’t large dx or dt if you are doing a high frequency simulation, or don’t input a high Nx or Nt if you only need to run a small simulation. Figuring out good values is informed by theory but optimized through practice.

Graphical user interface, application

Description automatically generated

## Creating a medium

Creating a medium consists of 4 parameters: **Density, Sound Speed, Alpha Coefficient, and Alpha Power.** The former two can be applied individually to each pixel/voxel. Moreover, note that density and sound speed relate to Young’s modulus (K) by The latter two alpha parameters must be uniform throughout the entire medium. This is not realistic, as these parameters do vary in actuality, and thus makes up a limitation of the program. Alpha coefficient effects how the pressure is attenuated over propagation. Alpha power effects the dispersive properties of the medium (how the sound speed varies with frequency). Higher alpha coef results in more attenuation, and higher alpha power results in faster dispersion into the different frequencies composing a broadband wave.

A medium can be created in two ways in KSIM. The first way is to use the four boxes provided in the many GUI itself and then pressing **Make Medium.** Doing it this way is simple and fast, but limited the simulation to a uniform medium. To create layered or heterogenous media, used the **Load CT** button. This brings up the load\_ct gui. For more information on using this gui for making 2D or 3D media, check out the [Load CT](#_Load_CT) section below.

Graphical user interface, diagram, application

Description automatically generated

## Creating sensors

Sensors in ksim represent the pixels/voxels of your grid at which output values will be calculated at during each time point of the simulation. Obviously, the more sensors used and more calculations made, the larger the output variables will be. Thus, careful calculation of sensor location is sometimes necessary to optimize simulation performance on slower computers or in special cases. However, for the most part, 2D simulations are small enough such that using all pixels as sensors is satisfactory and the simplest to run.

To use all pixels as sensors in a 2D simulation, simply check the **all** box and click **Make Sensor.** Also, make sure the **3D Sim** box remains unchecked. A simulation will always provide the pressures at each sensor. Additional parameters can be recorded by checking their specific boxes. However, it should be noted that no unique parameters can be calculated during the sim, i.e. all parameters can be calculated after simulation from the pressure. Therefore, in most cases, these additional parameters will be left unchecked.

For information on the other boxes, check the [3D simulation](#_Running_a_full) section.

Graphical user interface, application

Description automatically generated

## Creating an acoustic transducer

## Running and acoustic simulation

## Creating currents sources

## Running an acoustoelectric simulation

## Analyzing the results

# Running a full 3D acoustoelectric Simulation

# Load CT

# Electroids

# Automated functions

# Aberration Correction

## Analytical corrections

## Time Reversal

# adding noise

# Basic Analysis