k-Wave

A MATLAB toolbox for the time-domain simulation of acoustic wave fields

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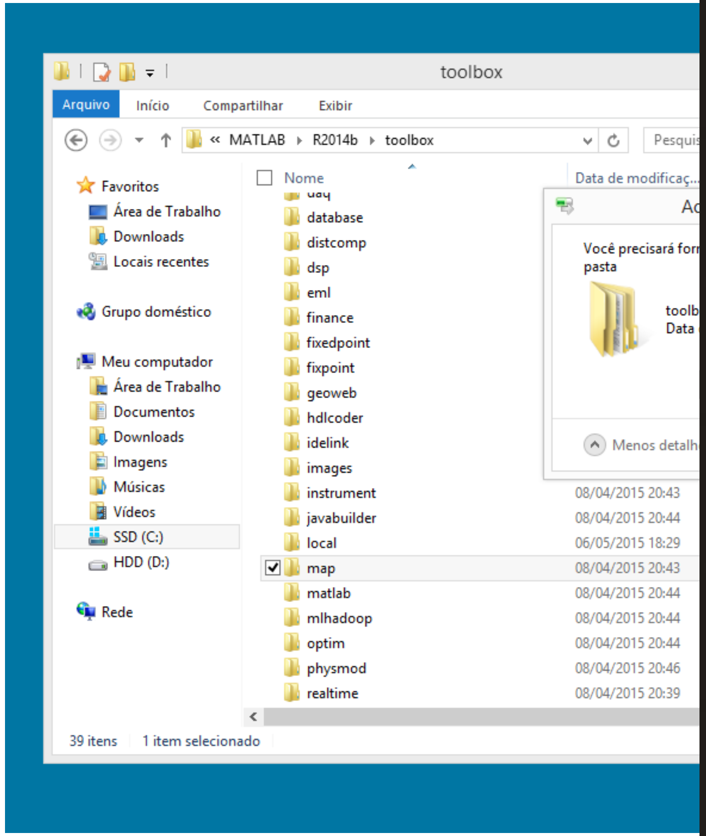
Potencial do k-Wave

- O software foi desenvolvido para simular a propagação de ondas e sistemas fotoacústicos em 1D, 2D ou 3D
- Exemplos de aplicações:
  - Propagação em meios homogêneos e heterogêneos,
  - funcionamento de transdutores comerciais e de formatos diversos,
  - efeito Doppler,
  - Difração, refração e reflexão
  - Fotoacústica, Modo-B etc

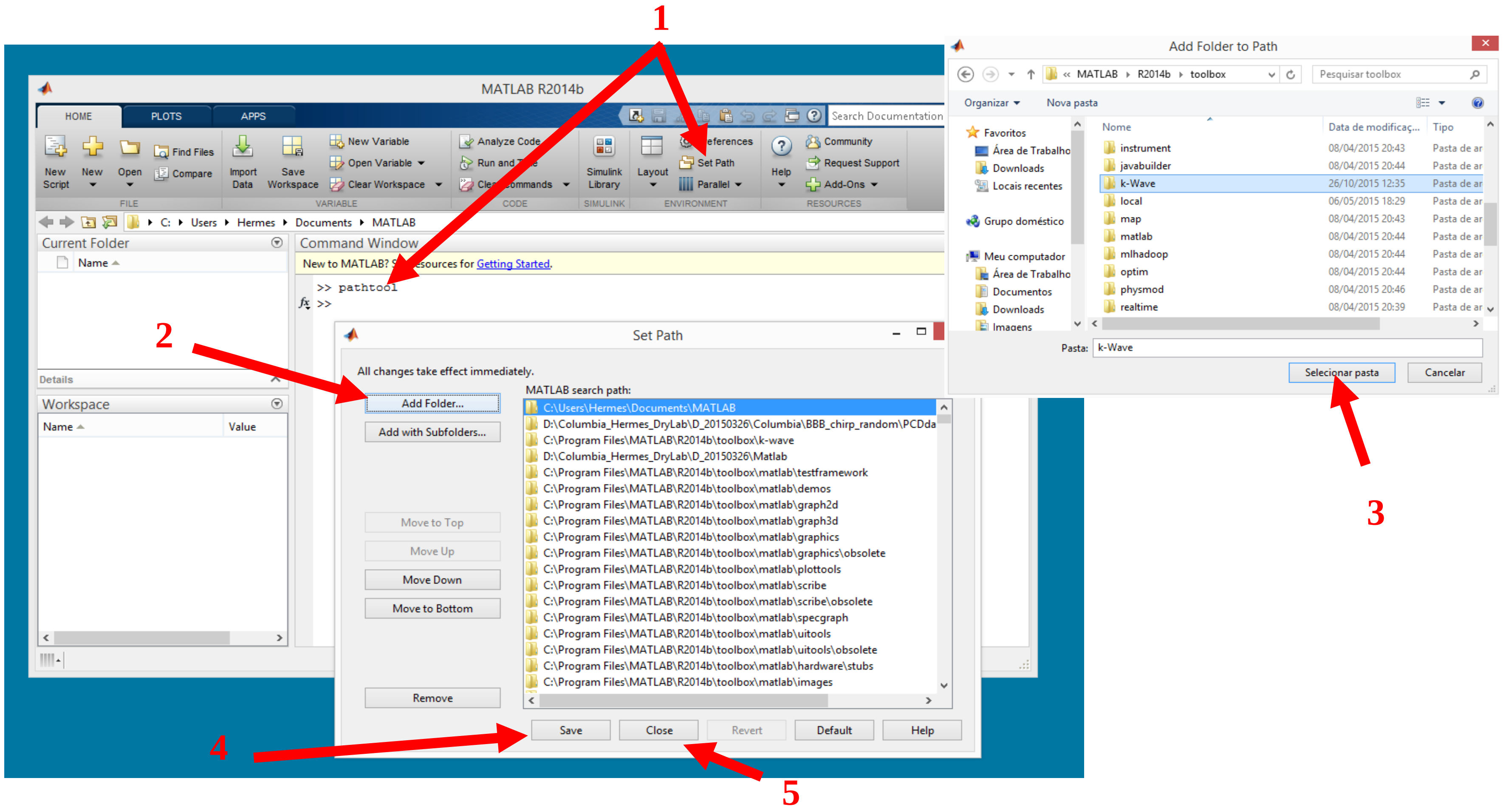
Instalação do k-Wave

- Download do arquivo
- Salvar pasta inteira em ./Matlab/R20XX/toolbox/



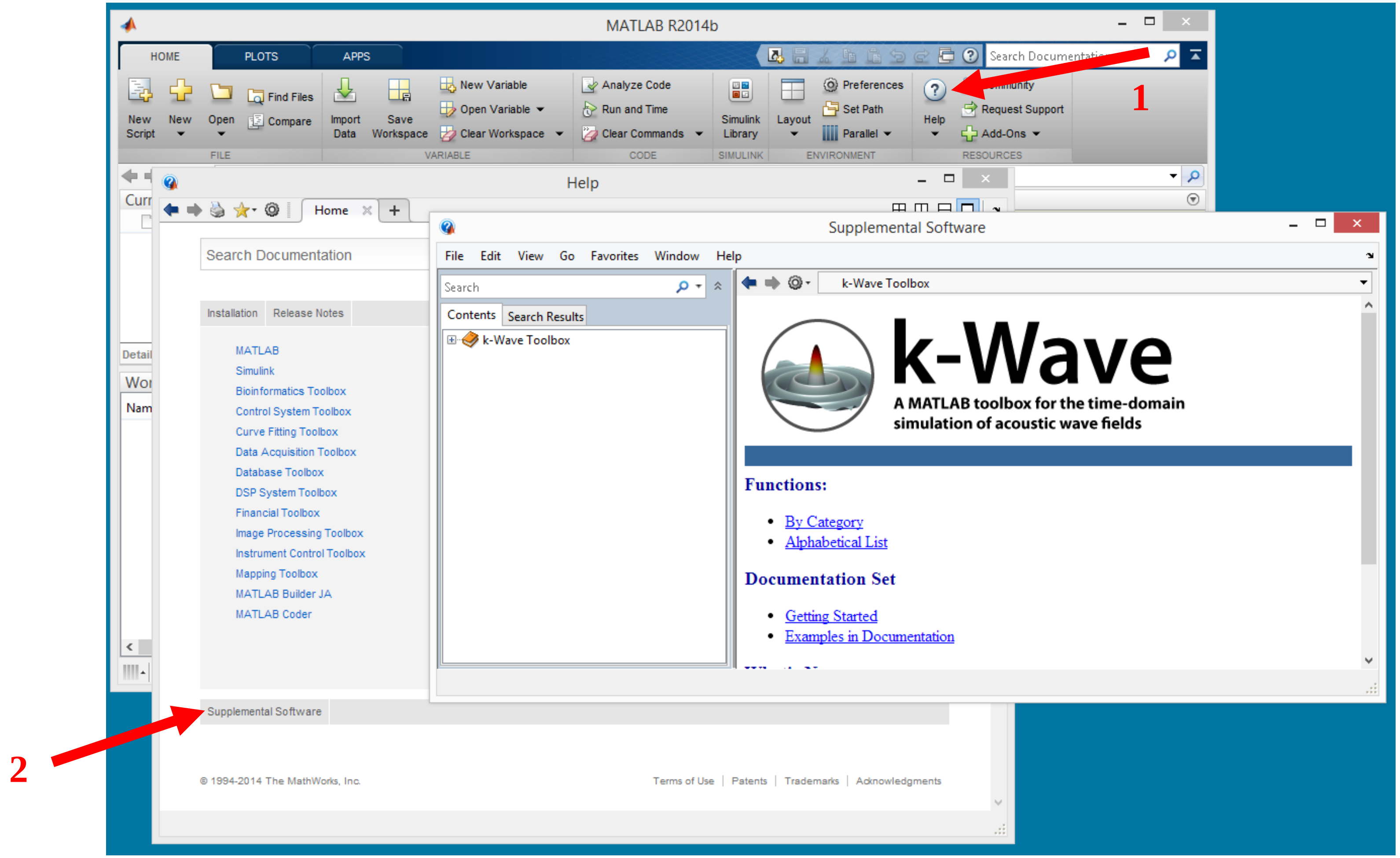
Instalação do k-Wave

- Abrir Matlab e incluir caminho para toolbox <File><Set Path><Add Folder><Save>



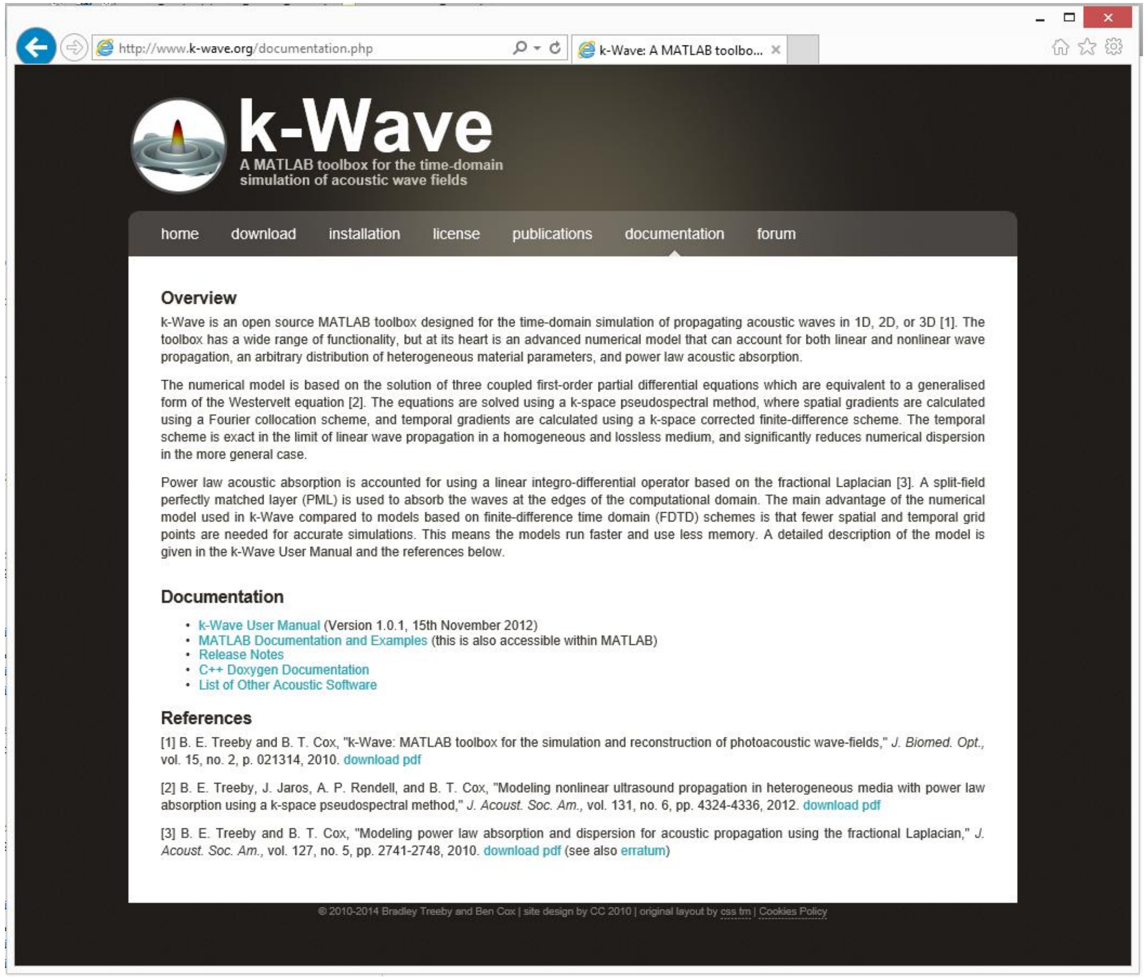
Instalação do k-Wave

- Reiniciar Matlab e abrir Help para ver se k-wave foi indexado na busca



Instalação do k-Wave

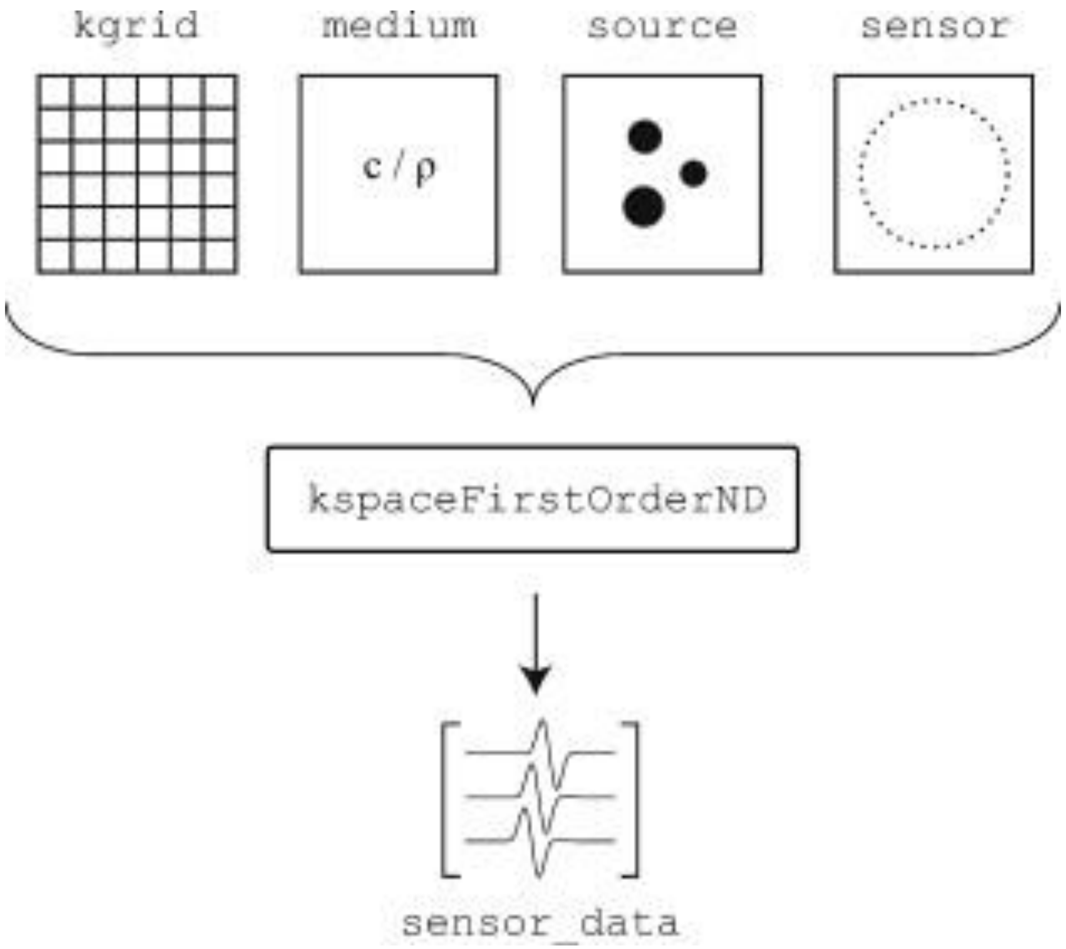
- Informações também disponíveis online



Algoritmo básico

- 1 - Definição:
- dos parâmetros do espaço a ser calculado
- dos Parâmetros do meio de propagação
- da fonte de ultrassom
- do sensor

- 2 - Rodar simulação
- 3 - Visualizar resultados



Algoritmo básico para utilização do K-Wave

Criação do seu ambiente de simulação (GRID)

```
% create the computational grid
Nx = 128;              % number of grid points in the x (row) direction
Ny = 128;              % number of grid points in the y (column) direction
dx = 0.1e-3;           % grid point spacing in the x direction  [m]
dy = 0.1e-3;           % grid point spacing in the y direction  [m]
kgrid = makeGrid(Nx, dx, Ny, dy);
```

Definir os parâmetros do meio

```
% define the properties of the propagation medium
medium.sound_speed = 1500;       % [m/s]
medium.alpha_coeff = 0.75;       % [dB/(MHz^y cm)]
medium.alpha_power = 1.5;
```

Criando um estimulo

```
% create initial pressure distribution using makeDisc
disc_magnitude = 5;              % [Pa]
disc_x_pos = 50;                 % [grid points]
disc_y_pos = 50;                 % [grid points]
disc_radius = 8;                 % [grid points]
disc_1 = disc_magnitude*makeDisc(Nx, Ny, disc_x_pos, disc_y_pos, disc_radius);

disc_magnitude = 3;              % [Pa]
disc_x_pos = 80;                 % [grid points]
disc_y_pos = 60;                 % [grid points]
disc_radius = 5;                 % [grid points]
disc_2 = disc_magnitude*makeDisc(Nx, Ny, disc_x_pos, disc_y_pos, disc_radius);

source.p0 = disc_1 + disc_2;
```

Algoritmo para utilização do K-Wave

Definir sensor de leitura

Executar a simulação

```
% define a centered circular sensor
sensor_radius = 4e-3;                              % [m]
num_sensor_points = 50;
sensor.mask = makeCartCircle(sensor_radius, num_sensor_points);


% run the simulation
sensor_data = kspaceFirstOrder2D(kgrid, medium, source, sensor);

% plot the simulated sensor data
figure;
imagesc(sensor_data, [-1, 1]);
colormap(getColorMap);
ylabel('Sensor Position');
xlabel('Time Step');
colorbar;
```

Algoritmo para utilização do K-Wave

Adicionando a variável tempo

```
% define a single source point
source.p_mask = zeros(Nx, Ny);
source.p_mask(end - Nx/4, Ny/2) = 1;

% define a time varying sinusoidal source
source_freq = 0.25e6;                    % [Hz]
source_mag = 2;                          % [Pa]
source.p = source_mag*sin(2*pi*source_freq*kgrid.t_array);

% define the acoustic parameters to record
sensor.record = {'p', 'p_final'};

% run the simulation
sensor_data = kspaceFirstOrder2D(kgrid, medium, source, sensor);
```

Exemplo de criação de um transdutor ultrassônico

% define properties of the input signal

source_strength = 1e6; % [MPa]

tone_burst_freq = 0.5e6; % [Hz]

tone_burst_cycles = 5; % create the input signal using toneBurst

input_signal = toneBurst(1/kgrid.dt, tone_burst_freq, tone_burst_cycles);

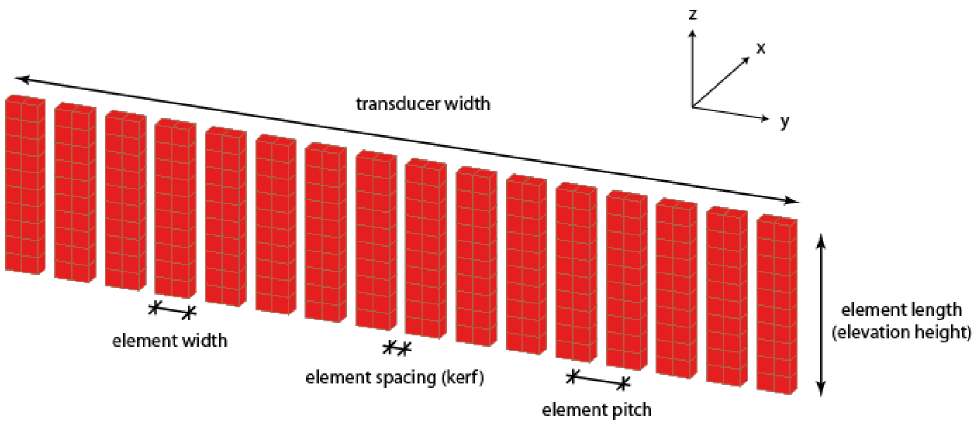
% scale the source magnitude by the source_strength divided by the

% impedance (the source is assigned to the particle velocity)

input_signal =

Exemplo de criação de um transdutor ultrassônico

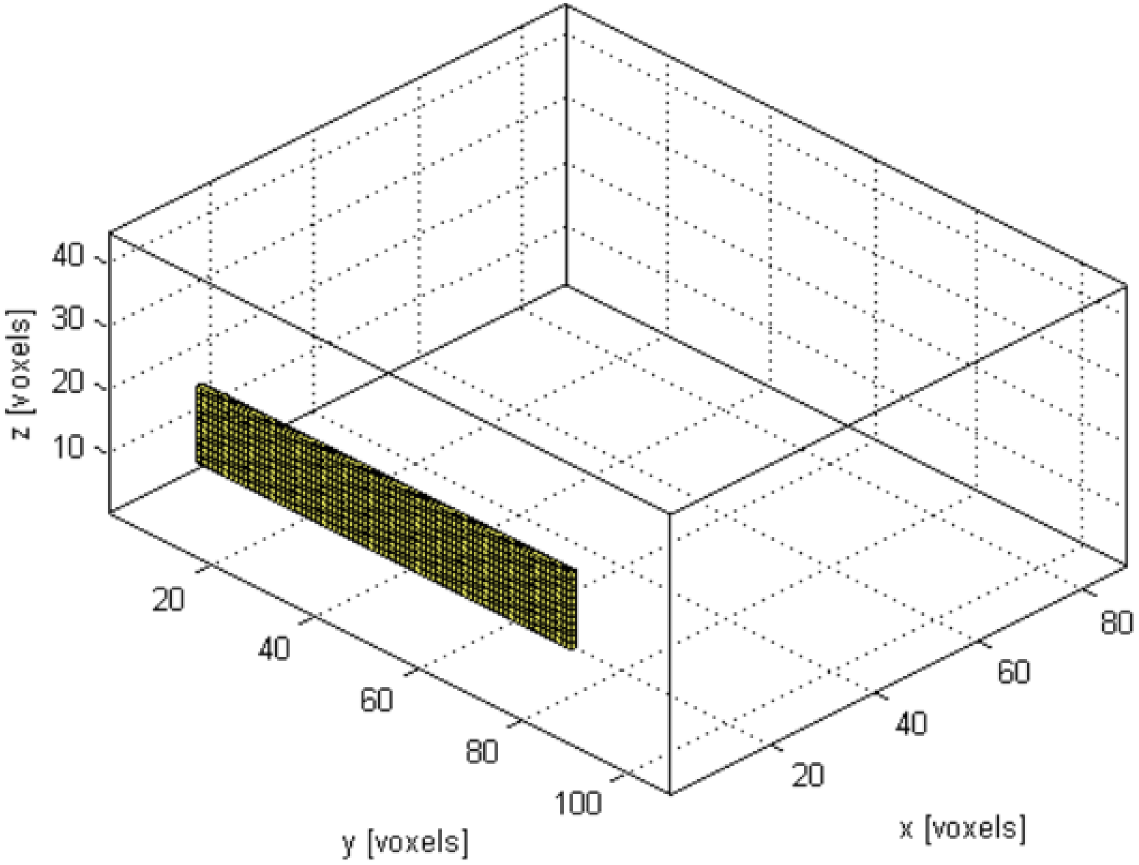
```
% physical properties of the transducer
transducer.number_elements = 72;       % total number of transducer elements
transducer.element_width = 1;          % width of each element [grid points]
transducer.element_length = 12;        % length of each element [grid points]
transducer.element_spacing = 0;        % spacing (kerf width) between the elements [grid points]
transducer.radius = inf;               % radius of curvature of the transducer [m]

% calculate the width of the transducer in grid points
transducer_width = transducer.number_elements*transducer.element_width + (transducer.number_elements - 1)*transducer.element_spacing;

% use this to position the transducer in the middle of the computational grid
transducer.position = round([1, Ny/2 - transducer_width/2, Nz/2 - transducer.element_length/2]);

% properties used to derive the beamforming delays
transducer.sound_speed = 1540;                  % sound speed [m/s]
transducer.focus_distance = 20e-3;              % focus distance [m]
transducer.elevation_focus_distance = 19e-3;    % focus distance in the elevation plane [m]
transducer.steering_angle = 0;                  % steering angle [degrees]

% apodization
transducer.transmit_apodization = 'Rectangular';
transducer.receive_apodization = 'Rectangular';
% define the transducer elements that are currently active
transducer.active_elements = zeros(transducer.number_elements, 1);
transducer.active_elements(21:52) = 1;
```



Exemplo de criação de um transdutor ultrassônico

Definindo o transdutor – Função *makeTransducer*

```
% append input signal used to drive the transducer
transducer.input_signal = input_signal;
% create the transducer using the defined settings
transducer = makeTransducer(kgrid, transducer);
```



Exemplo de criação de um transdutor ultrassônico

Executando a simulação

```
% run the simulation
[sensor_data] = kspaceFirstOrder3D(kgrid, medium, transducer, sensor, input_args{:})
```