

Make synthetic seismograms (based on FSM)

Introduction

This script generates synthetic seismograms.

For traveltimes modeling, the FSM method is used.

Synthetic seismograms are compared with FD results.

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Add MLIB library

```
clear; close all; clc;
mllibfolder = '/home/ivan/Desktop/MLIB';
path(path, mllibfolder);
add_mlib_path;
```

Set parameters of FD modeling

```
folder = [mllibfolder '/Examples/Heidimod/s90900/'];
vp = 4000; % velocity of P-wave
vs = 2350; % velocity of S-wave
rho = 3000; % density
ns = 130; % number of time samples
nts = 20; % number of time samples of the wavelet
dt = 0.002; % time step
nrec = 8; % number of receivers
f = 40; % dominant frequency
```

Make G-file

```
G=GridClass;

% [m] [m] [m] [s]
G.x0=0; G.y0=0; G.z0=0; G.t0 = 0.00; % initial point
G.nx=102; G.ny=103; G.nz=101; G.nt = ns; % grid size
G.dx=10; G.dy=10; G.dz=10; G.dt = dt; % grid step (meter)

G.gridInfo;
```

```
Information about grid:
x0=0, dx=10, Nx=102.
```

```
y0=0, dy=10, Ny=103.  
z0=0, dz=10, Nz=101.  
t0=0, dt=0.002, Nt=130.
```

```
G.setGrid;  
Gold = oldGrid(G);
```

Read results of FD modeling: source and receiver positions

```
fid = fopen([folder 'slocation'],'r');  
sloc = fread(fid, inf, 'single', 'ieee-be');  
fclose(fid);  
  
fid = fopen([folder 'geoloc'],'r');  
gloc = fread(fid, inf, 'single', 'ieee-be');  
fclose(fid);  
gloc = reshape(gloc,[3,nrec]);  
  
acq.gsx = sloc(2,:);  
acq.gsy = sloc(3,:);  
acq.gsz = sloc(1,:);  
acq.grx = gloc(2,:);  
acq.gry = gloc(3,:);  
acq.grz = gloc(1,:);  
acq.sx = G.x0 + (acq.gsx-1)*G.dx;  
acq.sy = G.y0 + (acq.gsy-1)*G.dy;  
acq.sz = G.z0 + (acq.gsz-1)*G.dz;  
acq.rx = G.x0 + (acq.grx-1)*G.dx;  
acq.ry = G.y0 + (acq.gry-1)*G.dy;  
acq.rz = G.z0 + (acq.grz-1)*G.dz;  
  
clear sloc gloc
```

Read results of FD modeling: seismograms

```
fid = fopen([folder 'arbxseis'],'r');  
datax = fread(fid, inf, 'single', 'ieee-be');  
fclose(fid);  
  
fid = fopen([folder 'arbyseis'],'r');  
datay = fread(fid, inf, 'single', 'ieee-be');  
fclose(fid);  
  
fid = fopen([folder 'arbzseis'],'r');  
dataz = fread(fid, inf, 'single', 'ieee-be');  
fclose(fid);  
  
datax = reshape(datax,[nrec ns 1]);  
datay = reshape(datay,[nrec ns 1]);  
dataz = reshape(dataz,[nrec ns 1]);
```

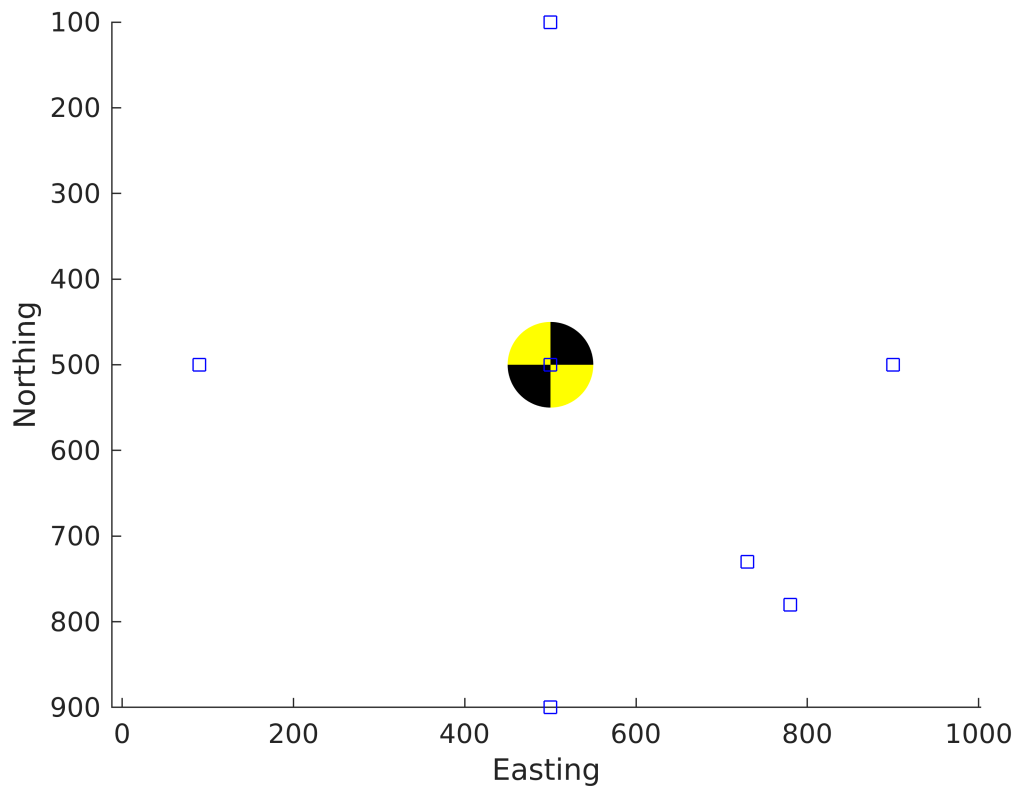
Read results of FD modeling: wavelet

```
fid = fopen([folder 'wavelet'],'r');
data = fread(fid, inf, 'single', 'ieee-be');
fclose(fid);
wavelet=reshape(data,[20,6,1]);
% wavelet 1 -- zz -- M33*ricker
% waveler 2 -- xx -- M11*ricker
% wavelet 3 -- zx -- M13 - M31*ricker
% wavelet 4 -- yy -- M22*ricker
% wavelet 5 -- zy -- M23 - M32*recker
% waverel 6 -- xy -- M12 - M21*ricker
```

Moment tensor

```
%M = [-.773 0.602 -0.041;0.602 0.729 0.266;-0.041 0.266 0.044];
M = [0 -1 0;-1 0 0;0 0 0];
%M = [0 0 1;0 0 0;1 0 0];
%M = compute_potency(45,45,0);
u = compute_displacement_iso(M,[1 .5]);

figure(2)
classic_beachball(u,[acq.sx,acq.sy,acq.sz],50);
hold on;
plot3(acq.rx,acq.ry,acq.rz,'bs');
xlabel('Easting');
ylabel('Northing');
zlabel('Depth');
view([0 0 -1])
```



Make velocity model and compute traveltimes of P- and S- waves

```
Pvelmod = 4000*ones(G.nx,G.ny,G.nz);
Svelmod = 2350*ones(G.nx,G.ny,G.nz);

S = [acq.sx, acq.sy, acq.sz];
Ptti = FSM3D(Gold, S, Pvelmod);
Stti = FSM3D(Gold, S, Svelmod);
```

Build synthetic wavelet

```
T = linspace((-nts/2+1)*G.dt, nts/2*G.dt, nts);
ww= -2e20.*(2.0*pi*f)*T.*exp(-(2*T*pi*f).^2);
ww = ww';
ww2 = -diff(ww,2)/G.dt^2;
%plot(ww)
```

Compute synthetic seismogram

```
seis = zeros(nrec,ns,3);

for r = 1:length(acq.rx)
```

```

% add P-wave
tp = Ptti(acq.grx(r),acq.gry(r),acq.grz(r));

n_p = [(Ptti(acq.grx(r)+1,acq.gry(r),acq.grz(r)) - Ptti(acq.grx(r)-1,acq.gry(r),acq.grz(r)))
        (Ptti(acq.grx(r),acq.gry(r)+1,acq.grz(r)) - Ptti(acq.grx(r),acq.gry(r)-1,acq.grz(r)))
        (Ptti(acq.grx(r),acq.gry(r),acq.grz(r)+1) - Ptti(acq.grx(r),acq.gry(r),acq.grz(r)-1))];

n_p = n_p/norm(n_p);

up = n_p*M*n_p';

dispp = up/(4*pi*rho*vp^3*tp).*n_p;
gtp = x2grid(tp,G.t0, G.dt, G.nt);
seis(r,(gtp+1):(gtp+18),:) = ww2*dispp;

% add S-wave
ts = Stti(acq.grx(r),acq.gry(r),acq.grz(r));

n_s = [(Stti(acq.grx(r)+1,acq.gry(r),acq.grz(r)) - Stti(acq.grx(r)-1,acq.gry(r),acq.grz(r)))
        (Stti(acq.grx(r),acq.gry(r)+1,acq.grz(r)) - Stti(acq.grx(r),acq.gry(r)-1,acq.grz(r)))
        (Stti(acq.grx(r),acq.gry(r),acq.grz(r)+1) - Stti(acq.grx(r),acq.gry(r),acq.grz(r)-1))];

n_s = n_s/norm(n_s);

us = zeros(1,3);
for i=1:3
    for j=1:3
        for k = 1:3
            us(i) = us(i) + (kronecker(i,j) - n_s(i)*n_s(j)) * n_s(k)*M(j,k);
        end
    end
end
% tem(r) = us
disps = us/(4*pi*rho*vs^3*ts);
gts = x2grid(ts,G.t0, G.dt, G.nt);
seis(r,(gts+1):(gts+18),:) = ww2*disps;
end

```

Plot results - FD

```

fig = figure(10);
subplot(1,3,1);
wiggles(datax(:,:));
title('X-Component','FontSize',15);
ylabel('nt','FontSize',15);
xlabel('Receiver','FontSize',15);
grid on
set(gca,'FontSize',15);

subplot(1,3,2);
wiggles(datay(:,:));
grid on

```

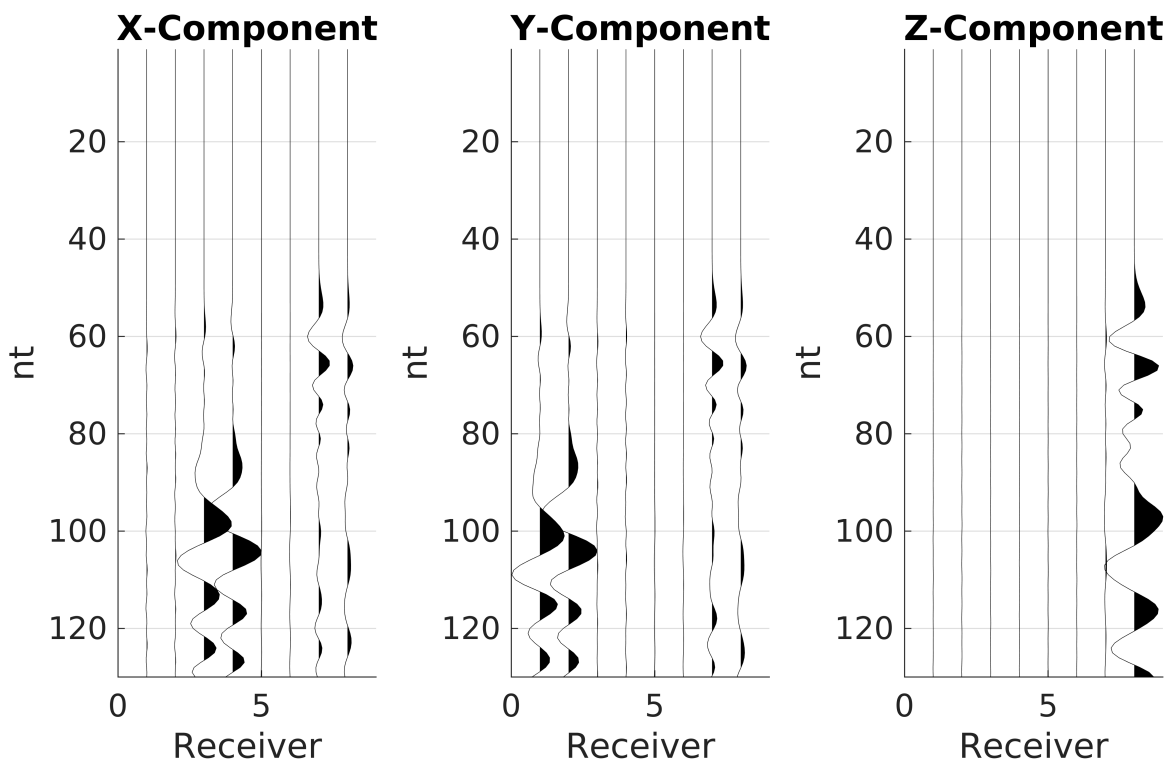
```

xlabel ('Receiver', 'FontSize',15)
title('Y-Component', 'FontSize',15);
ylabel ('nt', 'FontSize',15)
set(gca, 'FontSize',15);

subplot(1,3,3);
wiggles(dataz(:,:));
title('Z-Component', 'FontSize',15);
grid on
xlabel ('Receiver', 'FontSize',15)
ylabel ('nt', 'FontSize',15)
set(gca, 'FontSize',15);

set(fig, 'Position',[0 0, 900 500])

```



```

set(fig, 'PaperPositionMode', 'Auto')

```

Plot results - Ray tracing

```

fig = figure(12);
subplot(1,3,1);
wiggles(seis(:,:,1));
title('X-Component', 'FontSize',15);
ylabel ('nt', 'FontSize',15)
xlabel ('Receiver', 'FontSize',15)
grid on
set(gca, 'FontSize',15);

```

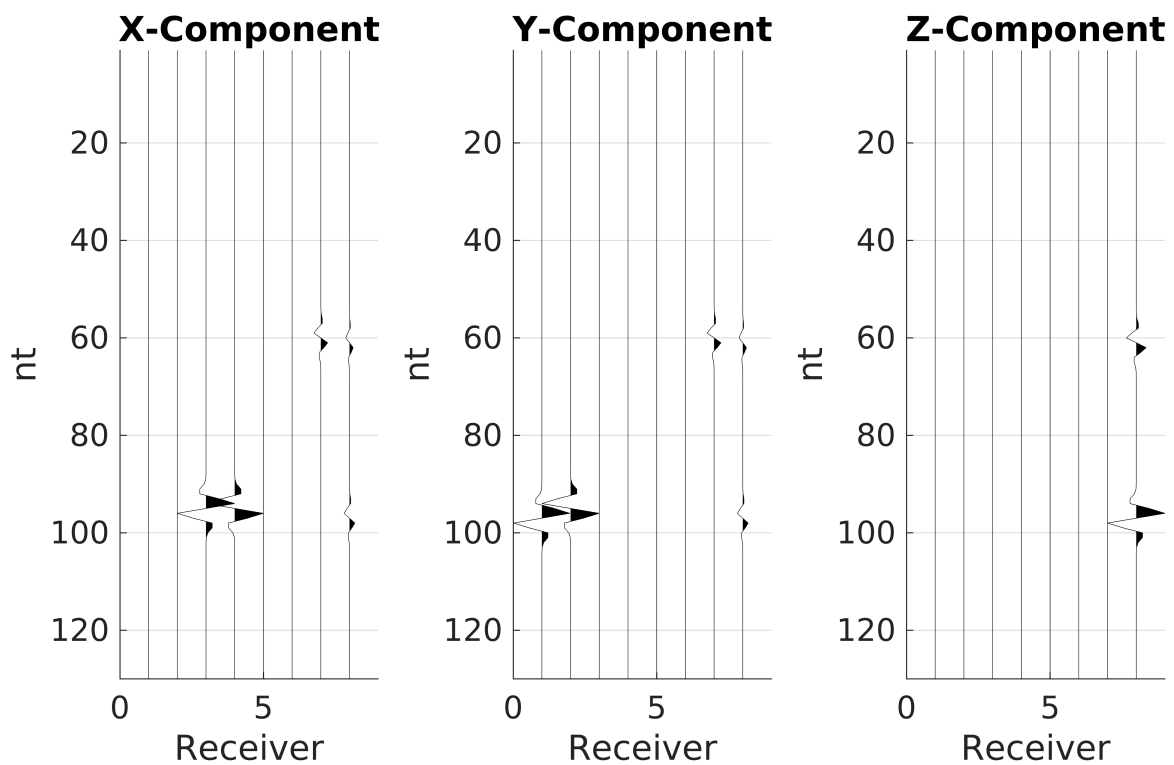
```

subplot(1,3,2);
wiggles(seis(:, :, 2));
grid on
xlabel ('Receiver', 'FontSize', 15)
title('Y-Component', 'FontSize', 15);
ylabel ('nt', 'FontSize', 15)
set(gca, 'FontSize', 15);

subplot(1,3,3);
wiggles(seis(:, :, 3));
title('Z-Component', 'FontSize', 15);
grid on
xlabel ('Receiver', 'FontSize', 15)
ylabel ('nt', 'FontSize', 15)
set(gca, 'FontSize', 15);

set(fig, 'Position', [0 0, 900 500])

```



```

set(fig, 'PaperPositionMode', 'Auto')

```