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Apêndice A

Neste apêndice estão listados alguns dos algoritmos desenvolvidos para este trabalho. Os algoritmos foram escritos em Matlab® e permitem realizar o processamento dos dados, análise de velocidades e gradiente descendente.

Quadro 1 mostra um algoritmo inspirado numa das rotinas do *anray* (Anray, 2002) que permite que os sismogramas sejam criados no matlab através da leitura dos dados de um dos arquivos de saída do *anray*. Quadro 2 permite o sorteio dos dados em CMPs, calculando os pontos médios (e afastamentos) dos dados e agrupando juntos em uma matriz de 3 dimensões.

Quadro 3 mostra a correção de NMO a partir da equação para anisotropia VTI (Alkhalifah & Tsvankin, 1995), onde os parâmetros V_{RMS} e η já foram obtidos na análise de velocidade e são dados de entrada para este algoritmo. Parte da rotina foi retirada de um algoritmo desenvolvido pelo Crewes (Crewes, 2002). Quadro 4 mostra uma das rotinas desenvolvidas para aplicar ganho no dado sísmico, com um ganho variável (AGC) (Yilmaz, 2001).

Quadro 5 é o algoritmo que calcula a análise de velocidade por *semblance* baseado em Taner & Koehler (1969). O Quadro 6 permite que a função de velocidade seja escolhida através de marcação no gráfico com o mouse.

O Quadro 7 mostra a função que calcula os parâmetros de anisotropia a partir do resultado do gradiente descendente. Já o Quadro 8 mostra o cálculo dos gradientes das diferentes funções utilizadas pelo método para realizar análise de velocidade necessárias para a utilização no método do gradiente descendente.

```
clear all;
close all;
% OBS1: Requer arquivo plotsismica.m!
% OBS2: Requer executar o syntan antes!
% OBS3: usar no mesmo diretorio do anray!

dos('anray < arq.txt'); % Executa o anray
dos('syntan < arqsynt2.txt'); % Executa o syntan

xx = [];
smax = [];
tmin = [];
npts = [];
s = [];
fid=fopen('tlu4');
mtext = fgetl(fid);
line2 = fgetl(fid);
l2 = str2num(line2);
    mdist = l2(1); % Numero de receptores
    mred = l2(2);  % Reducao de tempo de transito 0-nao
1-sim
    mcomp = l2(3);  % Componente plotada 0-vert 1-eixo_x
2-eixo_y
    itpr = l2(4); % 0-receptores_na_superficie 1-VSP
    vred = l2(5); % reducao de velocidade
    rstep = l2(6);  % passo de distancia entre
receptores
    xsour = l2(7);   % coordenada x da fonte
    ysour = l2(8);   % coordenada y da fonte
    dt = l2(9);  % passo de tempo para o sismograma
line3 = fgetl(fid);
    xmx = str2num(line3(23:32)); % receptor da amp
maxima
    smaxim = str2num(line3(42:56)); % amp maxima
    sismog = zeros(round(3/dt),mdist); % plotar para 5
segundos
    for i=1:mdist,     % Repete as duas linhas para
todos os receptores
        line4 = fgetl(fid);
        l4 = str2num(line4);
        xx = [xx l4(1)];  % coordenada do receptor
        smax = [smax l4(2)]; % amplitude maxima em xx
        tmin = [tmin l4(3)]; % tempo da primeira amp dif
de zero
        npts = [npts l4(4)]; % numero de pontos
        aux1 = 0;
        if npts(i) ~= 0,
            while aux1 < npts(i),
                line5 = fgetl(fid); %{CONSERTAR USANDO 4
caracteres para cada 1}
                for j=4:4:length(line5),
                    s = [s; str2num(line5(j-3:j))];
                end;
                aux1 = length(s); end;
            else
                line = fgetl(fid);
            end;
        ll = round(tmin(i)/dt);
        if npts(i) ~= 0,
            if ll ~= 0, sismog(ll:(ll-1+npts(i)),i) =
(smax(i)/999.1)*s;
            else sismog(1:(npts(i)),i) =
(smax(i)/999.1)*s;
            end;
            s = [];
        end;
    end;
    xrec = xx;
    sismog = -sismog;
    save sismograma sismog xrec xsour ysour dt
    figure,
plotsismica(agc(sismog),xrec,0:dt:((size(sismog,1)-
1)*dt));
    title('Sismograma sintetico')
```

Quadro 1: Criação de sismograma no Matlab

```
offset = zeros(size(xrec));
cmp = zeros(size(xrec));
n_cmp = [];
n_off = [];
for i = 1:size(xrec,1),
    for j = 1:size(xrec,2),
        temp0 = xrec(i,j) - xsou(j);
        offset(i,j) = (round(1000*temp0))*0.001;
        temp = (xsou(j) + xrec(i,j))/2;
        cmp(i,j) = (round(1000*temp))*0.001;
    end;
end;
n_cmp = cmp(1,1);
n_off = offset(1,1);for i = 1:size(xrec,1),
    for j = 1:size(xrec,2),
        if not(isempty(setdiff(cmp(i,j),n_cmp))), n_cmp
= [n_cmp cmp(i,j)]; end;
        if not(isempty(setdiff(offset(i,j),n_off))),
n_off = [n_off offset(i,j)]; end;
    end;
end;
ncmp = sort(n_cmp);
noff = sort(n_off);
s_cmp = zeros(size(s,1),length(noff),length(ncmp));
for i = 1:size(xrec,1),
    for j = 1:size(xrec,2),
        for k = 1:length(noff),
            for l = 1:length(ncmp),
                if
and(cmp(i,j)==ncmp(l),offset(i,j)==noff(k)),
s_cmp(:,k,l) = s(:,i,j); end;
            end;
        end;
    end;
end;

save cmpsorted s_cmp noff ncmp dt xsour ysour xrec
offset cmp
```

Quadro 2: Sorteio dos dados em CMPs

```
function [r,vel,nn] = nmo_vti(data,offset,dt,V,n);

if length(V)==1,
    vel = V*ones(size(data,1),1);
else vel = V;
    while length(vel)<size(data,1),
        vel = [vel; vel(length(vel))];
    end;
end;
if length(n)==1,
    nn = n*ones(size(data,1),1);
else nn = n;
    while length(nn)<size(data,1),
        nn = [nn; nn(length(nn))];
    end;
end;
tz = [0:dt:(size(data,1)-1)*dt];
t = tz';
r = zeros(size(data));
%i = 59;
for i = 1:length(offset),
    % --PEGUEI DO ALGORITMO DO CREWES ---
    % hout=nmor(h,t,v,x,dir)
    %compute the offset times
    tx=sqrt(t.^2 + ((offset(i).^2)./(vel.^2)) -
((2*nn.*(offset(i).^4))./((vel.^2).*(((t.^2).*(vel.^2))+
((1+2*nn).*(offset(i).^2))))));

    ind=between(t(1),t(length(t)),tx,2);

    if all(ind), r(ind,i)=sinci(data(:,i),t,tx(ind));
end;
    % -------------------------------------------
 end;
```

Quadro 3: Correção de NMO a partir da equação de Alkhalifah & Tsvankin (1995)

```
function sc=agc(sinal),

% Parametros de apoio
x = [zeros(15,size(sinal,2)); sinal ;
zeros(15,size(sinal,2))];
y =  x;
r = zeros(size(x));
a = 2000;
b = 30;
sc = zeros(size(sinal));

% Cálculo do RMS
for i = 1:size(x,2);
   for j = (b/2)+1:size(x,1)-(b/2);
      aux = 0;
      RMS = 0;
      for k = j-b/2:j+b/2;
         aux = aux + (x(k,i))^2;
      end;
      RMS = sqrt(aux)/b;
      if RMS~=0 y(j,i) = x(j,i)*a/RMS;
      else y(j,i) = x(j,i);
      end;
      r(j,i) = (RMS/a);
   end;
end;
r = r(16:15+size(sinal,1),:);
sc = y(16:15+size(sinal,1),:);
```

Quadro 4: Função de ganho variável (AGC)

```
function [R] =
semblance(data,offset,n_of_cmp,dt,V0,Vf,resp);

dti = size(data,1)*0.02;
dv = (Vf-V0)*0.02;
z = 0;
R = zeros(size(data,1),length(V0:dv:Vf));
for v = V0:dv:Vf,
    z = z + 1;
    if resp==1,
        [f1,vel_temp] =
nmo_vti(data(:,:,round(n_of_cmp/2)),offset,dt,v,0);
        f = agc(f1);
    elseif resp==2,
        load velocity;
        [f,vel_temp] =
nmo_vti(data(:,:,round(n_of_cmp/2)),offset,dt,vel_stack,
v);
    end;
    for ii = 1:size(data,1),
        t1 = ii;
        t2 = t1 + dti;
        if t2 > size(data,1), t2 = size(data,1); end;
        var1 = 0;
        var2 = 0;
        for i = t1:t2,
            tempf = 0;
            temps = 0;
            for j = 1:size(data,2),
                tempf = tempf + f(i,j);
                temps = temps + f(i,j)^2;
            end;
            var1 = var1 + (tempf)^2;
            var2 = var2 + temps;
        end;
        if var2 == 0, var2 = 0.0000000001; end;   % para
evitar o problema de divisao por zero
        num(ii) = var1;
        den(ii) = var2;
    end;
end;   % para evitar o problema de divisao
    R(:,z) = (num')./((size(data,2))*den');
end;
R = R.^4;
```

Quadro 5: Função de semblance (Taner & Koehler, 1969)

```
    [x,y] = getline;
    disp('Saved velocities!');
    j_file = round(y/dt);
    k = 0;
    for j = 1:j_file(length(j_file)),
        if isempty(setdiff(j,j_file)),
            k = k + 1;
            v(j) = x(k);
        else
            v(j) = 0;
        end;
    end;
    v = v';
    z = 0;
    nzero = find(v);
    if v(1) == 0,
        v(1) = x(1);
        i_nzero = 1;
        i_nzero1 = 1;
    end;
    for j = 1:length(v)-1,
        [c,i1,i2] = intersect(j,nzero);
        if not(isempty(c)),
            k = c;
            i_nzero = i2;
            z = 0;
            i_nzero1 = i_nzero + 1;
        else
            z = z + 1;
        end;
        if j < nzero(i_nzero1),
            deltan = nzero(i_nzero1) - nzero(i_nzero);
            deltavv = v(nzero(i_nzero1)) -
    v(nzero(i_nzero));
            vvref = v(nzero(i_nzero));
            z = z;
            if deltan ~= 0, vv(j) = vvref +
    z*(deltavv/deltan);
            else vv(j) = vvref;
            end;
        end;
    end;
    if resp==1,
        vel_stack = [vv'; v(length(v))];
        n_stack = zeros(size(vel_stack));;
    elseif resp==2,
        load velocity;
        n_stack = [vv'; v(length(v))];
    end;

    save velocity vel_stack n_stack data offset dt x y
```
Quadro 6: Marcação dos valores de velocidade a partir do gráfico de semblance

```
% script para rodar os Gradientes descendentes
%
% % Hiperbolico
% eq = 1;
% [a]=velangd(eq,data,dt,noff);
% t0_iso = sqrt(a(:,1))
% vnmo_iso = 1./sqrt(a(:,2))
%
%
% % Alkhalifah
eq = 2;
[a]=velangd(eq,data,dt,noff,x_events,t_events);
t0 = sqrt(a(:,1));
vrms = 1./sqrt(a(:,2));
eta = a(:,3);
vh = vrms(:).*sqrt(1+(2.*eta));
%
% % Perth
% eq = 3;
% [a]=velangd(eq,data,dt,noff);
% t0_perth = sqrt(a(:,1))
% vnmo_perth = 1./sqrt(a(:,2))
% vh_perth = 1./sqrt(a(:,3))
% eta_perth = a(:,4)
%
%
% % Castle
% eq = 4;
% [a]=velangd(eq,data,dt,noff,x_events,t_events);
% t0 = a(:,1);
% vrms = 1./sqrt(a(:,2));
% s = 1./a(:,3);
% eta = (s-1)./8;
% vh = vrms(:).*sqrt(1+(2.*eta));
%
% % VTI geral A e A4 - HORIZONTAL
% eq = 5;
% [a]=velangd(eq,data,dt,noff,x_events,t_events);
% t0 = sqrt(a(:,1));
% vrms = 1./sqrt(a(:,2));
% tempv = (a(:,3)./a(:,4)) + a(:,2);
% vh = 1./sqrt(tempv);
% eta = (((vh./vrms).^2) - 1)./2;
%
% % % VTI geral A e A4 - INCLINADO
% eq = 5;
% [a]=velangd(eq,data,dt,noff,x_events,t_events);
% t0 = sqrt(a(:,1));
% vrms = 1./sqrt(a(:,2));
% tempv = (a(:,3)./a(:,4)) + a(:,2);
% vh = 1./sqrt(tempv);
% eta = (((vh./vrms).^2) - 1)./2;

% -------------------------------------------------------
-------------------
% -------------------------------------------------------
-------------------
vint(1) = vrms(1);
vv(1) = vrms(1);
for q = 2:l,
    vint(q) = sqrt((((vrms(q)^2)*t0(q))-((vrms(q-
1)^2)*t0(q-1)))/(t0(q)-t0(q-1)));
    vv(q) = (vint(q)*(t0(q)-t0(q-1))+(vint(q-1)*t0(q-
1)))/(t0(q));
end;
for q = 1:l,
    epsilon1(q) = (vh(q)-vv(q))/(2*vv(q));
    delta(q) = (((vrms(q)/vv(q))^2)-1)/2;
    epsilon2(q) = (eta(q)*(1+(2*delta(q))))+delta(q);
    delta2(q) = (((vint(q)/v0(q))^2)-1)/2;
    epsilon3(q) = (eta(q)*(1+(2*delta2(q))))+delta2(q);
end;
```

Quadro 7: Calculo dos parâmetros de processamento a partir da saída do gradiente descendente

```
function [J]=grad_desc_eq(eq,a0,x,b,k)

if eq == 1,  % Hiperbolico
    J = [];
    f = a0(1) + ((x.^2).*a0(2));
    mx = 1 + (x.^2);
    J1 = (f-b)./mx;
    J2 = (f-b).*(x.^2)./mx;
    J = [J1 J2];

elseif eq == 2,   % Alkhalifah
    fnum = 2.*(a0(2).^2)*a0(3)*(x.^4);
    temp1 = 1+(2.*a0(3));
    fden = a0(1) + (temp1.*a0(2)*(x.^2));
    f = a0(1) + (a0(2).*(x.^2)) - (fnum./fden);
    mx = 1 + (x.^2) + (x.^4);
    J1 = ((f-b).*( 1 + (fnum/(fden.^2)) ))./mx;
    J2 = ((f-b).*((x.^2) - ( (
(4.*a0(2).*a0(3).*(x.^4).*(fden)) -
(temp1.*2.*(a0(2).^2).*a0(3).*(x.^6)) ) ./ ( fden.^2) )
))./mx;
    J3 = ((f-b).*(- ( (2.*(a0(2).^2).*(x.^4).*(fden)) -
(4.*(a0(2).^3).*a0(3).*(x.^6)) ) ./ (fden.^2) ))./mx;
    J = [J1 J2 J3];

elseif eq == 3,  % Perth
    J = [];
    v0 = k;      % Editar para cada caso
    fnum = (a0(3)-a0(2)).*2.*a0(4).*(x.^4);
    fden = (a0(1).*(v0.^4).*(a0(3)-a0(2))) -
(2.*a0(4).*(x.^2));
    f = a0(1) + ((x.^2).*a0(2)) - (fnum./fden);
    mx = 1 + (x.^2) + (x.^4);
    J1 = ((f-b).*( 1 + (((v0.^4)*(a0(3)-
a0(2)).*fnum)./(fden.^2)) ))./mx;
    J2 = ((f-b).*((x.^2) - ( ( (-
2.*a0(4).*(x.^4).*(fden)) + (fnum.*(a0(1).*(v0.^4))) )
./ ( fden.^2) ) ))./mx;
    J3 = ((f-b).*(- ( (2.*a0(4).*(x.^4).*(fden)) -
((v0.^4).*a0(1).*(fnum)) ) / (fden.^2) ))./mx;
    J4 = ((f-b).*(- ( (2.*(a0(3)-a0(2)).*(x.^4)*(fden))
+ ((x^2).*2.*(fnum)) ) / (fden.^2) ))./mx;
    J = [J1 J2 J3 J4];

elseif eq == 4,   % Castle
    temp1 =
sqrt(((a0(1).^2).*(a0(3).^2))+(a0(2).*a0(3).*(x.^2)));
    m = ((1-a0(3)).*a0(1))+temp1;
    mx = 1 + (x.^2);
    J1 = ((m-b).*((1-
a0(3))+((a0(1).*(a0(3).^2))./temp1)))./mx;
    J2 = ((m-b).*((0.5).*(x.^2).*a0(3)./temp1))./mx;
    J3 = ((m-b).*(-
a0(1)+(0.5.*((2.*(a0(1).^2).*a0(3))+((x.^2).*a0(2)))./te
mp1)))./mx;
    J = [J1 J2 J3];

elseif eq == 5,   % VTI geral A e A4
    fnum = a0(3)*(x^4);
    fden = 1 + (a0(4)*(x^2));
    f = a0(1) + ((x^2)*a0(2)) + (fnum/fden);
    mx = 1 + (x^2) + (x^4);
    J1 = ((f-b)*1)/mx;
    J2 = ((f-b)*(x^2))/mx;
    J3 = ((f-b)*((x^4) / (fden) ))/mx;
    J4 = ((f-b)*(- ((x^2)*(fnum)) / (fden^2) ))/mx;
    J = [J1 J2 J3 J4];

end;
```

Quadro 8: Cálculos dos gradientes das funções de análise de velocidade para utilização no método.