

```

% trav07a.m
% solve first problem of homework 3, fall-07

x=[3915.74;2873.49;2351.8;3356.20;2197.94];
y=[9228.31;8492.34;6328.2;5824.15;5005.78];
% ef
%x(3)=2351.78736373034;
%y(3)=6328.2048063928;
% br
x(3)=2351;
y(3)=6328;
sigma_sec=5;
sigd_fix=0.02;
sigd_ppm=3;
a123d=138+46/60+51/3600;
a234d=103+5/60+41/3600;
a345d=298+6/60+28/3600;
d23=2226.13;
d34=1123.85;
degrad=180/pi;
secrad=180*3600/pi;
a123=a123d/degrad;
a234=a234d/degrad;
a345=a345d/degrad;
l=[a123;a234;a345;d23;d34];

% calcs for init. appx;
% su
azm21=atan2(x(1)-x(2),y(1)-y(2));
azm23=azm21+a123;
x3apx=x(2) + d23*sin(azm23);
y3apx=y(2) + d23*cos(azm23);
x(3)=x3apx;
y(3)=y3apx;
% lh
x(3)=2500;
y(3)=6800;
x3apx=x(3);
y3apx=y(3);
% jw
x(3)=2200;
y(3)=6500;
x3apx=x(3);
y3apx=y(3);
% ke
x(3)=2334.11;
y(3)=6325.18
x3apx=x(3);
y3apx=y(3);
% gn
x(3)=2351;
y(3)=6328
x3apx=x(3)
y3apx=y(3)

n=5;
n0=2;
r=n-n0;
% solve by indirect observations
u=2; % x3,y3
c=5;

sigma=sigma_sec/secrad;
sigd23=sigd_fix + (sigd_ppm/10^6)*d23;
sigd34=sigd_fix + (sigd_ppm/10^6)*d34;
W=eye(5);
W(1,1)=1/sigma^2;
W(2,2)=1/sigma^2;
W(3,3)=1/sigma^2;
W(4,4)=1/sigd23^2;
W(5,5)=1/sigd34^2;
sig0=1;
sig0sqr=1;

converged=0;
for iter=1:10
    disp('iteration!');
    iter
    B=zeros(c,u);
    f=zeros(c,1);

    % angle 123

```

```

dxij=x(1)-x(2);
dyij=y(1)-y(2);
dxik=x(3)-x(2);
dyik=y(3)-y(2);
Dsqij=dxij^2 + dyij^2;
Dsqik=dxik^2 + dyik^2;
B(1,1)=-dyik/Dsqik;
B(1,2)=dxik/Dsqik;
compij=atan2(dxij,dyij);
if(compij < 0)
    compij=compij + 2*pi;
end
compik=atan2(dxik,dyik);
if(compik < 0)
    compik + 2*pi;
end
comp=compik-compij;
if(comp < 0)
    comp=comp + 2*pi;
end
obs=a123;
F=obs-comp;
f(1)=-F;

% angle 234

dxij=x(2)-x(3);
dyij=y(2)-y(3);
dxik=x(4)-x(3);
dyik=y(4)-y(3);
Dsqij=dxij^2 + dyij^2;
Dsqik=dxik^2 + dyik^2;
B(2,1)=dyik/Dsqik - dxij/Dsqij;
B(2,2)=-dxik/Dsqik + dxij/Dsqij;
compij=atan2(dxij,dyij);
if(compij < 0)
    compij=compij + 2*pi;
end
compik=atan2(dxik,dyik);
if(compik < 0)
    compik + 2*pi;
end
comp=compik-compij;
if(comp < 0)
    comp=comp + 2*pi;
end
obs=a234;
F=obs-comp;
f(2)=-F;

% angle 345

dxij=x(3)-x(4);
dyij=y(3)-y(4);
dxik=x(5)-x(4);
dyik=y(5)-y(4);
Dsqij=dxij^2 + dyij^2;
Dsqik=dxik^2 + dyik^2;
B(3,1)=dyij/Dsqij;
B(3,2)=-dxij/Dsqij;
compij=atan2(dxij,dyij);
if(compij < 0)
    compij=compij + 2*pi;
end
compik=atan2(dxik,dyik);
if(compik < 0)
    compik=compik + 2*pi;
end
comp=compik-compij;
if(comp < 0)
    comp=comp + 2*pi;
end
obs=a345;
F=obs-comp;
f(3)=-F;

% distance 23

dxij=x(3)-x(2);
dyij=y(3)-y(2);
Dij=sqrt(dxij^2 + dyij^2);
B(4,1)=-dxij/Dij;
B(4,2)=-dyij/Dij;

```

```

obs=d23;
comp=Dij;
F=obs-comp;
f(4)=-F;

% distance 34

dxij=x(4)-x(3);
dyij=y(4)-y(3);
Dij=sqrt(dxij^2 + dyij^2);
B(5,1)=dxij/Dij;
B(5,2)=dyij/Dij;
obs=d34;
comp=Dij;
F=obs-comp;
f(5)=-F;

% ok now solve the LS problem

if(iter == 1)
    B
    W
    f
end
N=B'*W*B;
t=B'*W*f;
del=inv(N)*t;
del
x(3)=x(3)+del(1);
y(3)=y(3)+del(2);
if(all(abs(del) < 10e-06))
    converged=1;
    break;
end
end

if converged
disp('we have converged');
x(3)
y(3)
v=f-B*del
v1sec=v(1)*seccad
v2sec=v(2)*seccad
v3sec=v(3)*seccad
lhat=1+v
alhat=r2dms(lhat(1))
a2hat=r2dms(lhat(2))
a3hat=r2dms(lhat(3))
test_stat=v'*W*v/sig0sq
% compare against chi-sqr with r eof
% 2-sided test, alpha=0.01
cv1=chi2inv(0.005,r)
cv2=chi2inv(0.995,r)
if((test_stat>cv1) & (test_stat<cv2))
    disp('pass global test');
    S=sig0sq*inv(N)
    [evec,eval]=eig(S)
    lam1=eval(1,1)
    lam2=eval(2,2)
    if(eval(2,2)>eval(1,1))
        % sort/order by magnitude
        disp('swap eigen val/vec');
        tmp=eval(2,2);
        eval(2,2)=eval(1,1);
        eval(1,1)=tmp;
        tmp=evec(:,2);
        evec(:,2)=evec(:,1);
        evec(:,1)=tmp;
        lam1=eval(1,1)
        lam2=eval(2,2)
    end
    p=0.99
    chisqr_2p=chi2inv(p,2)
    disp('semi major axis');
    ax1=sqrt(chisqr_2p*lam1)
    evec(:,1)
    disp('semi minor axis');
    ax2=sqrt(chisqr_2p*lam2)
    evec(:,2)
    px=[-ax1*evec(1,1) ax1*evec(1,1)];
    py=[-ax1*evec(2,1) ax1*evec(2,1)];
    plot(px,py,'-', 'linewidth',2);
    hold on

```

```

trav07a.m
px=[-ax2*evect(1,2) ax2*evect(1,2)];
py=[-ax2*evect(2,2) ax2*evect(2,2)];
plot(px,py,'-', 'linewidth',2);
th=atan2(evect(2,1),evect(1,1));
mx=[cos(-th) sin(-th);-sin(-th) cos(-th)];
alph=0:2*pi/100:2*pi;
xx=ax1*cos(alph);
yy=ax2*sin(alph);
plist=[xx;yy];
px=mx(1,:)*plist;
py=mx(2,:)*plist;
plot(px,py,'r-', 'linewidth',2);
axis equal
title('99 percent confidence ellipse traverse problem fall 07');
else
disp('fail global test');
end

else
disp('we failed to converge');
end

```

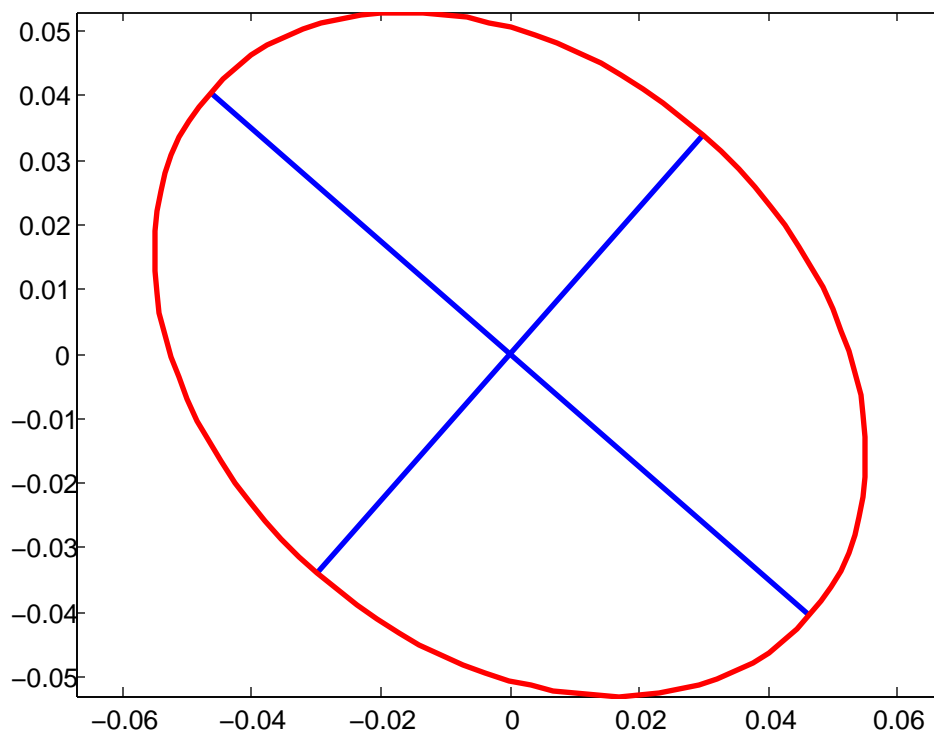
```

trav07a
x3apx =      2351.78736373034
y3apx =      6328.2048063928
iteration
iter =
  1
B =
  0.000436700151853793      -0.00010527420891009
 -0.000835819974302155      -0.00069003810230799
  0.000399119822448362      0.000795312311218079
   0.234354074681018        0.972151309046284
  0.893768278228906        -0.448529001104429
W =
Columns 1 through 3
  1701806811.84609          0          0
   0          1701806811.84609          0
   0          0          1701806811.84609
   0          0          0
   0          0          0
Columns 4 through 5
   0          0
   0          0
   0          0
  1405.01436956823        0
   0          1830.73282512897
f =
   0
  1.87153745074831e-005
 -4.98794731385033e-006
   0
 -0.0546486366665704
del =
 -0.0409417677828851
  0.0161869829304196
iteration
iter =
  2
del =
 -8.79324352891967e-008
 -3.99010346029885e-008
we have converged
ans =
      2351.74642187463
ans =
      6328.22099333583
v =
  1.95834362528987e-005
 -4.33495757141484e-006
 -1.52105148829517e-006
  -0.00614084027255045
  -0.0107957846343744
v1sec =
      4.0393736843565
v2sec =
 -0.894149183557264
v3sec =
 -0.313739390525061
lhat =
  2.42220206376442
  1.79933800924917
  5.20296072697432
 2226.12385915973
 1123.83920421537
alhat =
      138
      46
 55.0393736843853
a2hat =
      103
      5
 40.105850816434
a3hat =
      298
      6
 27.6862606094846
test_stat =
  0.954931993161821
cv1 =
  0.071721774586492
cv2 =
  12.8381564665986

```

```
pass global test
S =
  0.000330062726765383 -9.43534959750701e-005
 -9.43534959750701e-005  0.000304628552726747
evect =
  0.752852413864305  0.658189367081154
 -0.658189367081153  0.752852413864305
eval =
  0.000412552291325534  0
  0  0.000222138988166596
lam1 =
  0.000412552291325534
lam2 =
  0.000222138988166596
p =
  0.99
chisqr_2p =
  9.21034037197618
semi major axis
ax1 =
  0.0616420880920402
ans =
  0.752852413864305
 -0.658189367081153
semi minor axis
ax2 =
  0.045232462799418
ans =
  0.658189367081154
  0.752852413864305
diary off
```

99 percent confidence ellipse traverse problem fall 07



```

% sevpar2.m 25-nov-07
% 7 parameter transformation

X=[100;120;120;100];
Y=[20;20;35;35];
Z=[5;5;5;5];
x=[97.03;114.00;114.28;97.31];
y=[21.82;21.53;34.72;34.52];
z=[3.20;4.09;2.98;2.09];
l=[x(1);y(1);z(1);X(1);Y(1);Z(1);
    x(2);y(2);z(2);X(2);Y(2);Z(2);
    x(3);y(3);z(3);X(3);Y(3);Z(3);
    x(4);y(4);z(4);X(4);Y(4);Z(4)];
l0=l;
% approximations
% lambda: 0.85
% omega: 5 deg
% phi: 3 deg
% kappa: 0.5 deg
% tx: 12
% ty: 5
% tz: -4
degrad=180/pi;
par=[0.85;5/degrad;3/degrad;0.5/degrad;12;5;-4];
par=[1;0;0;0;0;0;0];

n=24;
n0=19;
r=5;
u=7;
c=r+u;

sig=0.02;
sigsqr=sig^2;
W=eye(24);
sig0=1;
sig0sqr=1;
for i=1:24
    W(i,i)=1/sigsqr;
end
old_vtwv=9.9e+06;
for iter=1:10
    iter
    A=zeros(c,n);
    B=zeros(c,u);
    f=zeros(c,1);
    lam=par(1);
    om=par(2);
    ph=par(3);
    kp=par(4);
    tx=par(5);
    ty=par(6);
    tz=par(7);
    m=m3(kp)*m2(ph)*m1(om);
    x=[l0(1);l0(7);l0(13);l0(19)];
    y=[l0(2);l0(8);l0(14);l0(20)];
    z=[l0(3);l0(9);l0(15);l0(21)];
    X=[l0(4);l0(10);l0(16);l0(22)];
    Y=[l0(5);l0(11);l0(17);l0(23)];
    Z=[l0(6);l0(12);l0(18);l0(24)];
    for i=1:4
        rndx=(i-1)*3 + 1;
        cndx=(i-1)*6 + 1;
        a=[1 0 0 -lam*m(1,1) -lam*m(1,2) -lam*m(1,3);
            0 1 0 -lam*m(2,1) -lam*m(2,2) -lam*m(2,3);
            0 0 1 -lam*m(3,1) -lam*m(3,2) -lam*m(3,3)];
        A(rndx:rndx+2,cndx:cndx+5)=a;
        dm1=[0 0 0;0 -sin(om) cos(om);0 -cos(om) -sin(om)];
        dm2=[-sin(ph) 0 -cos(ph);0 0 0;cos(ph) 0 -sin(ph)];
        dm3=[-sin(kp) cos(kp) 0;-cos(kp) -sin(kp) 0;0 0 0];
        V=[X(i);Y(i);Z(i)];
        u0=-m*V;
        u1=-lam*m3(kp)*m2(ph)*dm1*V;
        u2=-lam*m3(kp)*dm2*m1(om)*V;
        u3=-lam*dm3*m2(ph)*m1(om)*V;
        b=[u0(1) u1(1) u2(1) u3(1) -1 0 0;
            u0(2) u1(2) u2(2) u3(2) 0 -1 0;
            u0(3) u1(3) u2(3) u3(3) 0 0 -1];
        B(rndx:rndx+2,:)=b;
        v=[x(i);y(i);z(i)];
        t=[tx;ty;tz];
        F=v - lam*m*V -t;
        f(rndx:rndx+2)=-F;
    end
end

```



```

    if(iter==1)
        a
    end
end
f=f - A*(1-l0);
if(iter==1)
    B
    f
    disp('element of weight matrix');
    W(1,1)
end
Q=inv(W);
Qe=A*Q*A';
We=inv(Qe);
N=B'*We*B;
t=B'*We*f;
del=inv(N)*t
par=par+del;
resid=Q*A'*We*(f-B*del);
l0=l+resid;
vtwv=resid'*W*resid;
converged=0;
if(abs(vtwv-old_vtwv) < 1.0e-08)
    converged=1;
    break;
end
old_vtwv=vtwv;
end
if converged
    disp('we converged');
    par
    omega_d=par(2)*degrad
    phi_d=par(3)*degrad
    kappa_d=par(4)*degrad
    test_stat=vtwv/sig0sqr
    % alpha=0.05;
    cv1=chi2inv(0.025,r)
    cv2=chi2inv(0.975,r)
    if((test_stat > cv1) & (test_stat < cv2))
        disp('we passed global test');
    else
        disp('we did not pass global test');
        sig0sqr_hat=vtwv/r;
        S=sig0sqr_hat*inv(N);
        % P=50%, alpha=0.5
        % 1 - alpha/2 = 0.75
        disp('redundancy');
        r
        disp('t for P=0.75, r');
        tt=tinv(0.75,r)
        sig_scale=sqrt(S(1,1));
        hlf=tt*sig_scale;
        scale=par(1)
        sig_scale
        disp(' +/- for 50% interval');
        hlf
        disp('range');
        [scale-hlf scale+hlf]
    end
else
    disp('we failed to converge');
end

```

```

sevpar2
iter =
1
a =
  1   0   0  -1   0   0
  0   1   0   0  -1   0
  0   0   1   0   0  -1
a =
  1   0   0  -1   0   0
  0   1   0   0  -1   0
  0   0   1   0   0  -1
a =
  1   0   0  -1   0   0
  0   1   0   0  -1   0
  0   0   1   0   0  -1
a =
  1   0   0  -1   0   0
  0   1   0   0  -1   0
  0   0   1   0   0  -1
B =
-100   0   5  -20  -1   0   0
 -20  -5   0  100   0  -1   0
  -5   20 -100   0   0   0  -1
-120   0   5  -20  -1   0   0
 -20  -5   0  120   0  -1   0
  -5   20 -120   0   0   0  -1
-120   0   5  -35  -1   0   0
 -35  -5   0  120   0  -1   0
  -5   35 -120   0   0   0  -1
-100   0   5  -35  -1   0   0
 -35  -5   0  100   0  -1   0
  -5   35 -100   0   0   0  -1
f =
      2.97
     -1.82
      1.8
      6
     -1.53
      0.91
      5.72
    0.2800000000000001
      2.02
      2.69
    0.4799999999999997
      2.91
element of weight matrix
ans =
2500
del =
-0.1462800000000001
0.07399999999999996
0.04450000000000002
0.008159999999999941
      11.7439
    5.197799999999996
   -4.038600000000003
iter =
2
del =
0.00199770351695476
0.0121993183583394
0.0083062032182929
-0.000241437140196586
-0.155159903715926
-0.121037923617787
-0.072475040402459
iter =
3
del =
3.89278414901733e-005
-7.33964119020142e-005
4.35223972675512e-005
-2.860360800399e-005
-0.00225302717057849
-0.00192998523396432
-0.00699955500466277
iter =
4
del =
5.59521424816329e-008
1.89020154247184e-006
-2.88562126540372e-008
2.31326701848806e-007

```

```
-1.38594997969887e-005
 1.60099658749412e-005
 4.69400953923326e-005
iter =
 5
del =
 2.55538741057917e-009
-1.43854787864213e-008
 2.98306193353519e-009
-2.01504400519046e-009
-1.94552928079857e-007
-2.26515638338239e-007
-6.43676824699833e-007
iter =
 6
del =
 3.6484271797397e-012
 2.91583265511257e-010
-1.98145871682871e-011
 1.67463619601887e-011
-1.30221031472907e-009
 8.28254546735759e-010
 8.76364164864971e-009
we converged
par =
 0.855756689869622
 0.0861277980540839
 0.0528496997225953
 0.00789018858020304
 11.5864730137586
 5.0748478754267
-4.11802829022494
omega_d =
 4.93475932725407
phi_d =
 3.02806474263843
kappa_d =
 0.452074505207953
test_stat =
 176.328125354789
cv1 =
 0.831211613486663
cv2 =
 12.83250199403
we did not pass global test
redundancy
r =
 5
t for P=0.75, r
tt =
 0.726686843800423
scale =
 0.855756689869622
sig_scale =
 0.00625302461171773
+/- for 50% interval
hlf =
 0.00454399071929552
range
ans =
 0.851212699150327
diary off 0.860300680588918
```