Paper: Sparse multidimensional exponential analysis with an application to radar imaging.

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4.3. 3-dimensional fighter jet example

Contents

Script environment

This script depends on the random number generator state.

```
clear
close all
```

4.3. 3-dimensional fighter jet example

In a larger scale example of 1000 scatterers depicting the surface of a fighter jet [37], we take the radar parameters as in Section 4.1, add noise with SNR=20 dB and further choose $N = 6000, \nu = 2000, \eta = 1500, \mathrm{n} = 6000, \kappa = 11, \mathrm{p} = 0.4$ with $\Delta_1 = (-2.2371, 0.2796, 0.8389), \Delta_2 = (1.6528, -1.6528, 4.9584), \Delta_3 = (0.4744, 2.1350, 0.5535)$. The density δ in DBSCAN was varied over $2^\ell \times 10^{-5}, \ell = 0, \ldots, 10$ while m_δ was kept at $m_\delta = \lceil 0.8\kappa \rceil = 9$.

When dealing with the $\exp(\Phi_{ji}), i = 2, 3$ we discard cluster results with a standard deviation above 0.5. We remark that as the density δ increases, the probability increases that a candidate cluster, detected among the Δ_1-projections, is not confirmed in each and every one of the Δ_i-projections, $i = 2, \ldots, d$. Rejection dominates acceptance from $\ell = 7$ on.

In the end, the above algorithm detects and validates 516 scatterers (out of 1000), but misses out on the scatterers that are located too closely together or for which the inner products in (4.1) are too much alike. Although the overall shape of the fighter is correctly recognized (nose, wing tips, tail, ...), which may be more than satisfactory for many applications, the accuracy of the algorithm can be improved in the region where several scattering centers (x_j, y_j, z_j) are located near one another, such as the windshield. To this end the algorithm needs to be combined with a sub-Nyquist technique, particularly suitable for

the exponential analysis of such signals [9]. This final addition to the algorithm is explained in the next section. We also point out that, thanks to the validation step, there are no false results.

```
load('fighter_1000')

figure;
scatter3(fighter_x, fighter_y, fighter_z, 7,'filled',...
        'MarkerFaceColor','k')
xlabel('X'); ylabel('Y'); zlabel('Z');
grid on
view([60,20])
hold on
h = plot(shp);
h.FaceColor = [96,96,96]/255;
h.EdgeColor = [96,96,96]/255;
h.FaceAlpha = 0.1;
h.EdgeAlpha = 0.1;
axis([-15 15 -15 15 -5 10]);
title('Fig. 7: Fighter jet original 1000 scattering center data')


object_parms.loc = [fighter_x; fighter_y; fighter_z];
object_parms.ampl = s_i;
c = physconst('LightSpeed');

ISAR_parms.df = 0.0015e9;
ISAR_parms.dtheta = 3.75e-04;
ISAR_parms.dphi = 3.75e-04;

ISAR_parms.f0 = 7.9e9;
ISAR_parms.theta0 =  -0.024;
ISAR_parms.phi0 = -0.024;
ISAR_parms.fc = 8.4e9;

delta = [ -8, 1, 3 ;
       2,  -2, 6 ;
       6, 27 , 7];

for k = 1:3
    bound = 1.1*max(4/c*abs(ISAR_parms.df*...
                object_parms.loc(1,:)*delta(k,1)...
            + ISAR_parms.fc*ISAR_parms.dtheta*...
                object_parms.loc(2,:)*delta(k,2)...
            + ISAR_parms.fc*ISAR_parms.dphi*...
```

```
                object_parms.loc(3,:)*delta(k,3)));
    delta(k,:) = delta(k,:)/bound;
end

ISAR_parms.delta = delta;

signal_parms.nsamples = 6000;
signal_parms.SNR = 20;
signal_parms.overlap = 0.6;
signal_parms.nwindow = 11;

ESPRIT_parms.ncols = 2000;
ESPRIT_parms.nrows = 4001;
ESPRIT_parms.nterms = 1500;

clust_parms.MinPts = 9;
clust_parms.epsvec = 2.^(0:10)*1e-5;
clust_parms.disc_eps = 0.5;
clust_parms.lb = 0.7;
clust_parms.ub = 1.3;

data = create_signal(object_parms, ISAR_parms, signal_parms);
loc = ISARsolver(data,ISAR_parms,ESPRIT_parms,clust_parms,false);

figure;
scatter3(loc(1,:), loc(2,:), loc(3,:), 7,'filled',...
        'MarkerFaceColor','r')
xlabel('X'); ylabel('Y'); zlabel('Z');
grid on
view([60,20])
hold on
h = plot(shp);
h.FaceColor = [96,96,96]/255;
h.EdgeColor = [96,96,96]/255;
h.FaceAlpha = 0.1;
h.EdgeAlpha = 0.1;
axis([-15 15 -15 15 -5 10]);
title(['Fig. 8: Fighter jet reconstruction of 516 out ',...
       'of 1000 scatterers'])
```

Fig. 7: Fighter jet original 1000 scattering center data

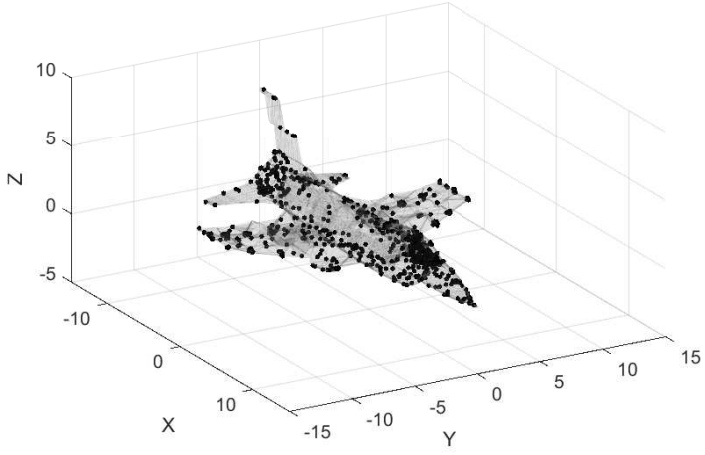

Fig. 8: Fighter jet reconstruction of 516 out of 1000 scatterers