

**Lab # 5**  
**PCA-based EEG signal processing**

Raed Suftah

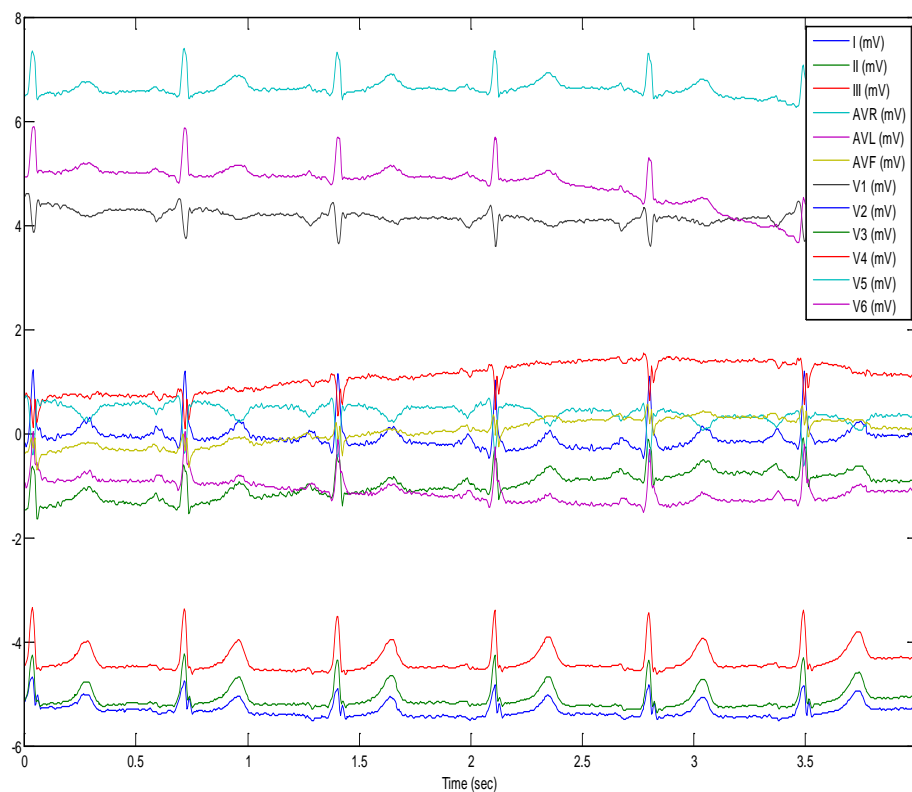
110-44-889

**Q1. Principle Component Analysis. Develop a function that can perform PCA through 4 steps: (1) mean subtraction, (2) covariance matrix calculation, (3) SVD decomposition, (4) data projection.**

**A:** The function is given below with the main code.

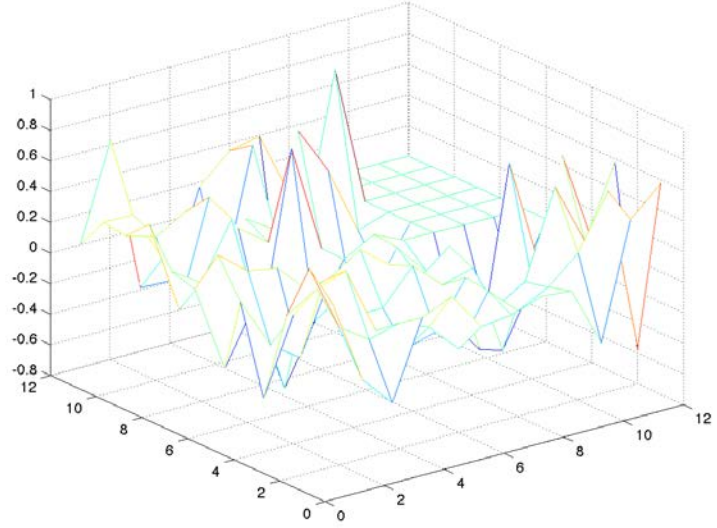
**Q2. EEG Feature Extraction. Use the above PCA function to process the 32 sets of EEG data, each containing 12 channels of signals. Display the projected signals of 12 channels for each dataset. Compute the principal component for each dataset. Visualize 32 sets of principal components in 3D.**

**A:** One of the 12 leads EEG signal is here:

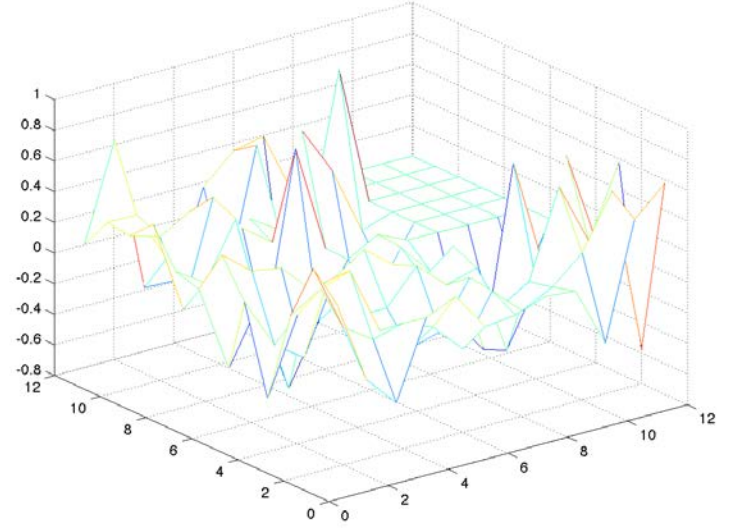


The 32 sets of 12 channels EEG data are displayed here: I cut the 1000 length of data for each channel each set. There are so many figures for each set. Here I just put first 10 figures to show the results of projected signals of 12 channels.

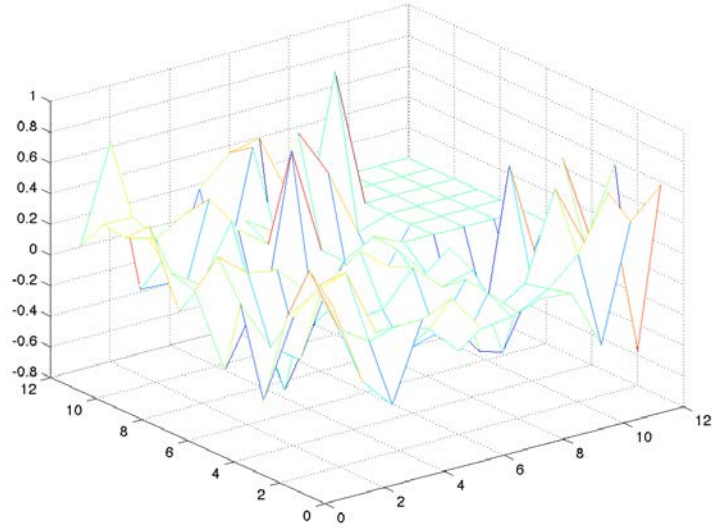
PCA for ID 1



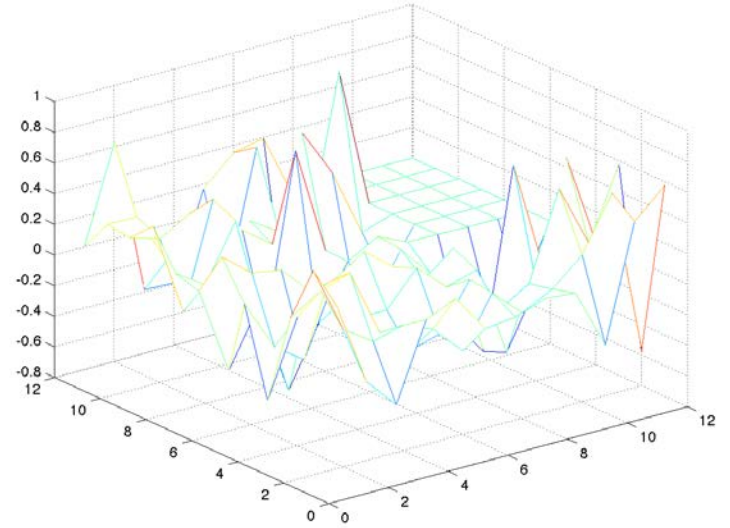
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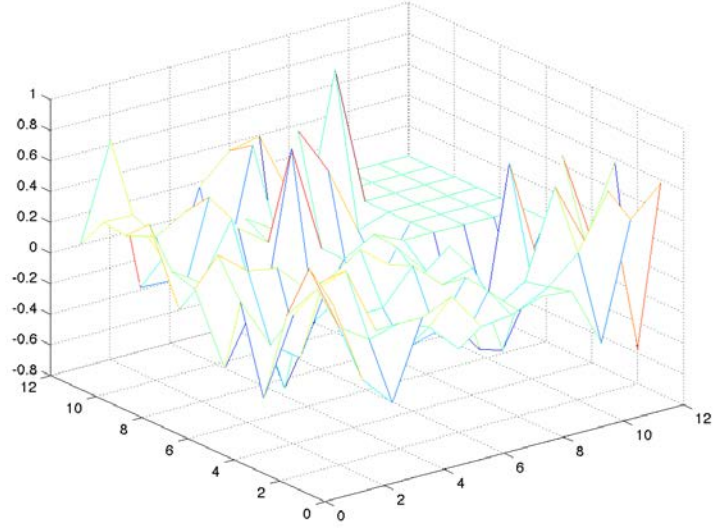
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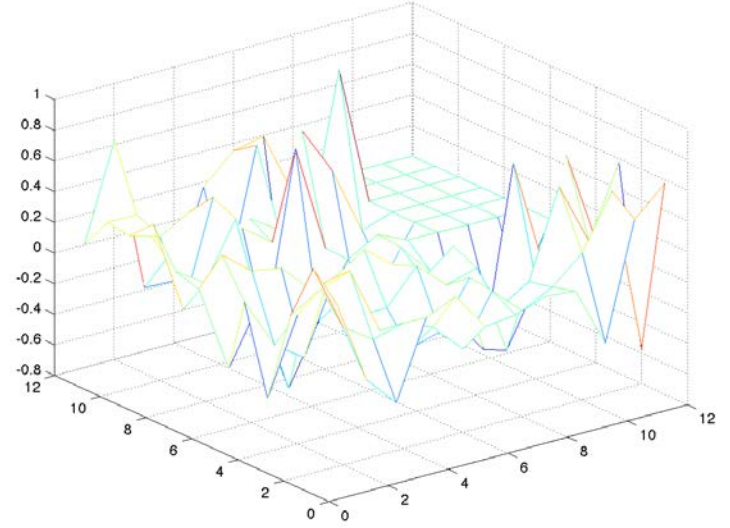
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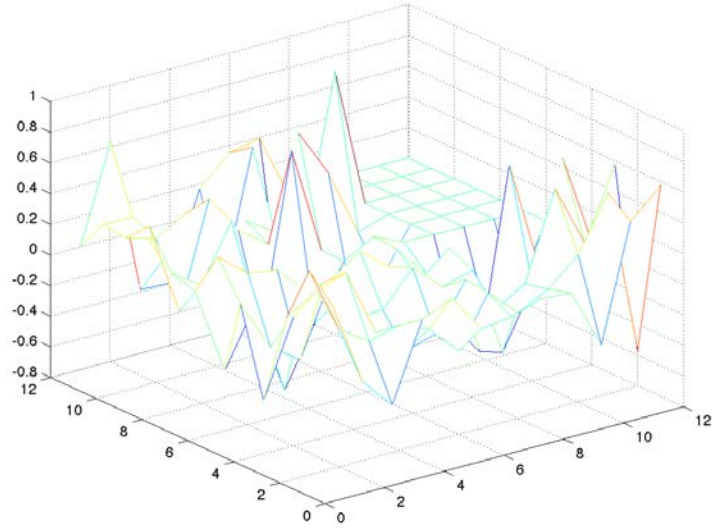
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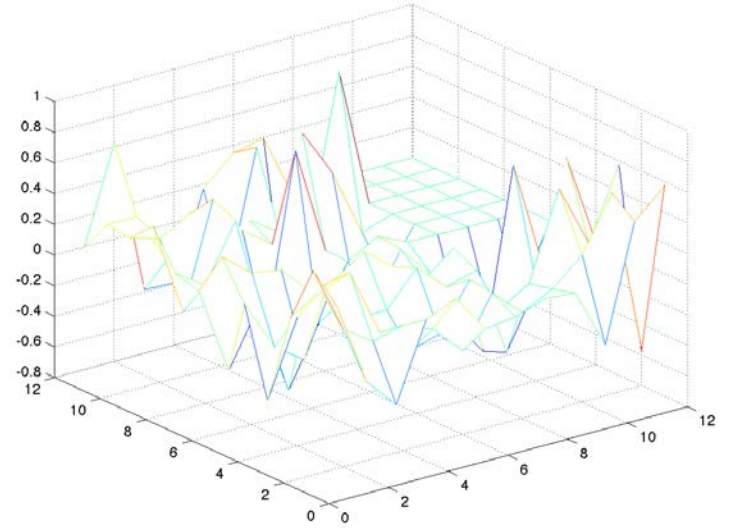
PCA for ID 7



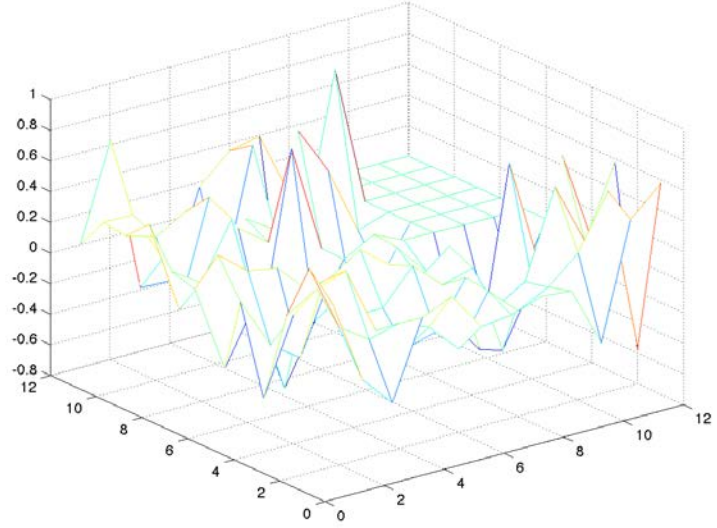
PCA for ID 6



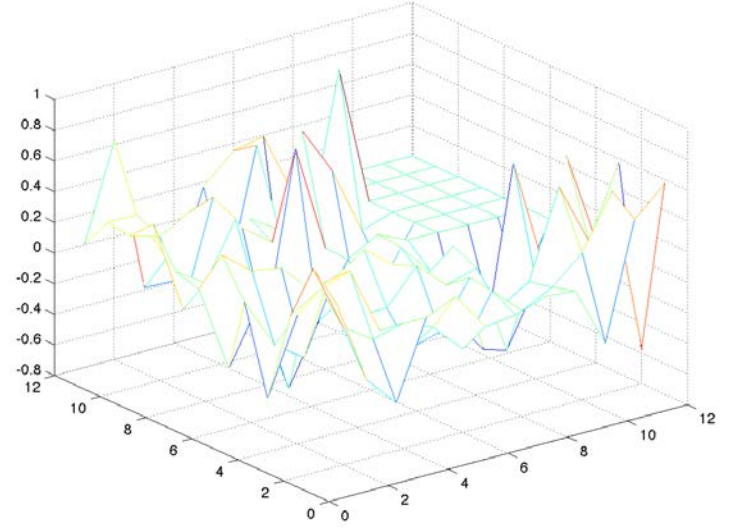
PCA for ID 8



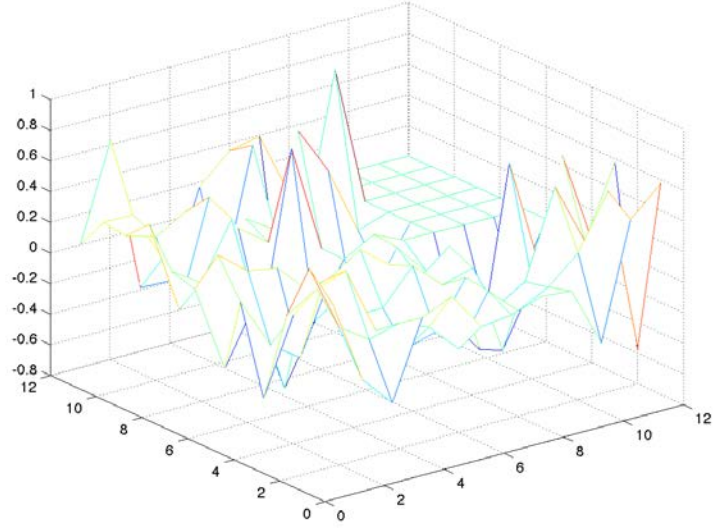
PCA for ID 9



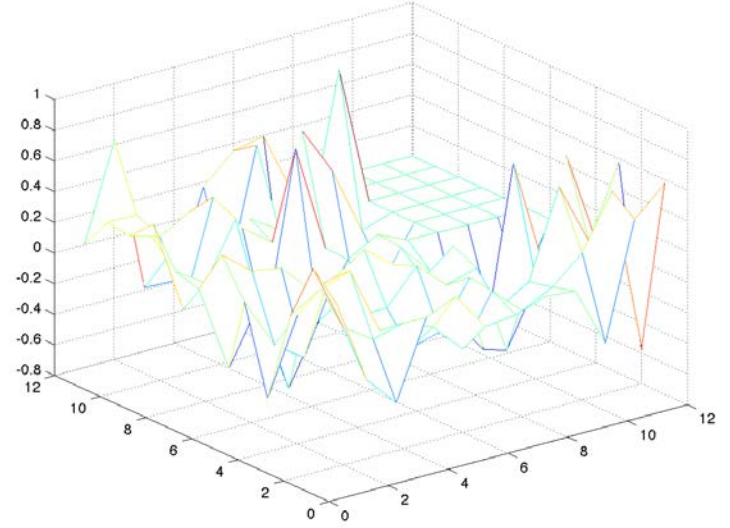
PCA for ID 11



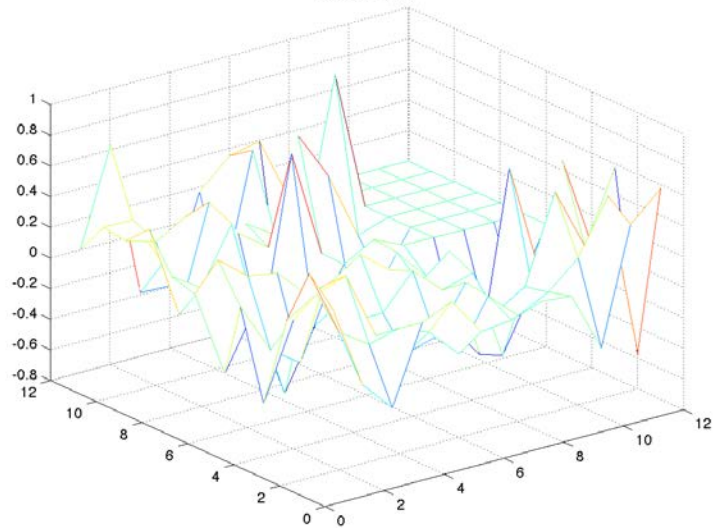
PCA for ID 10



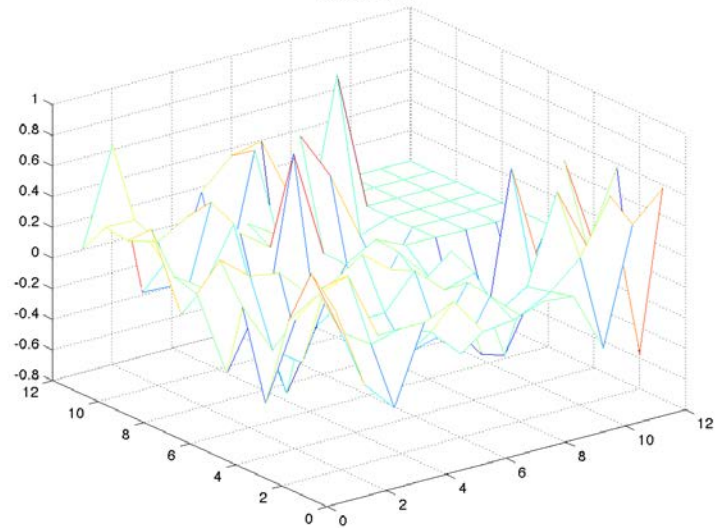
PCA for ID 12



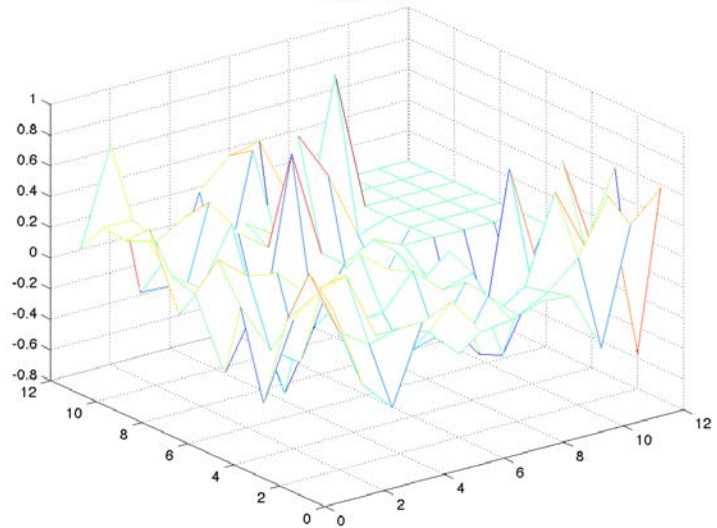
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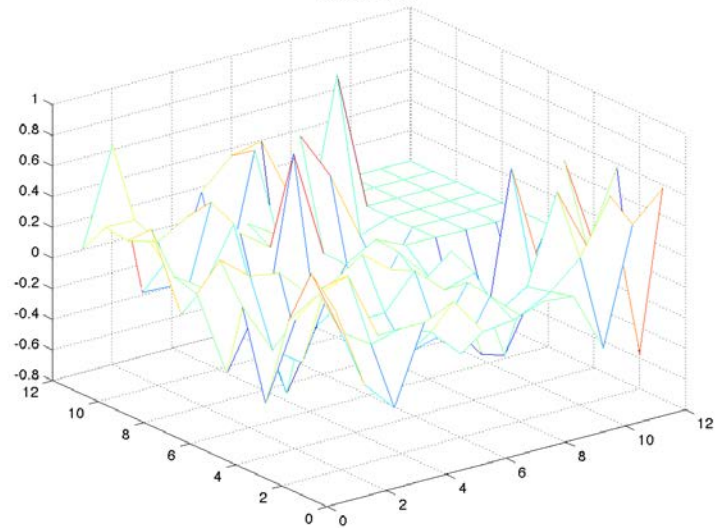
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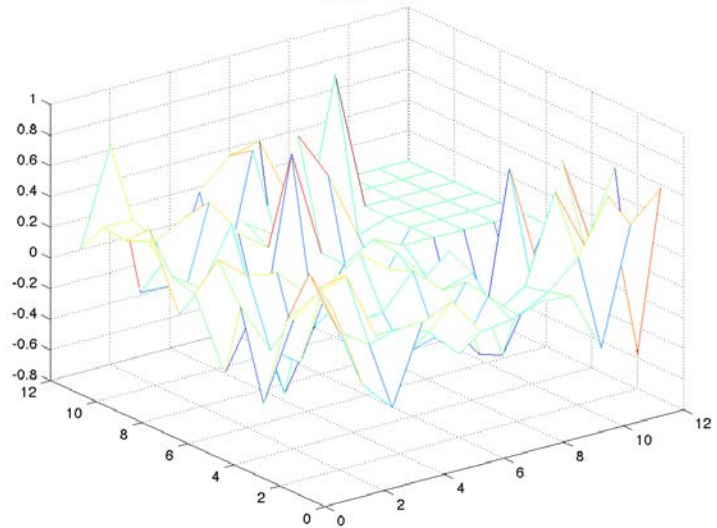
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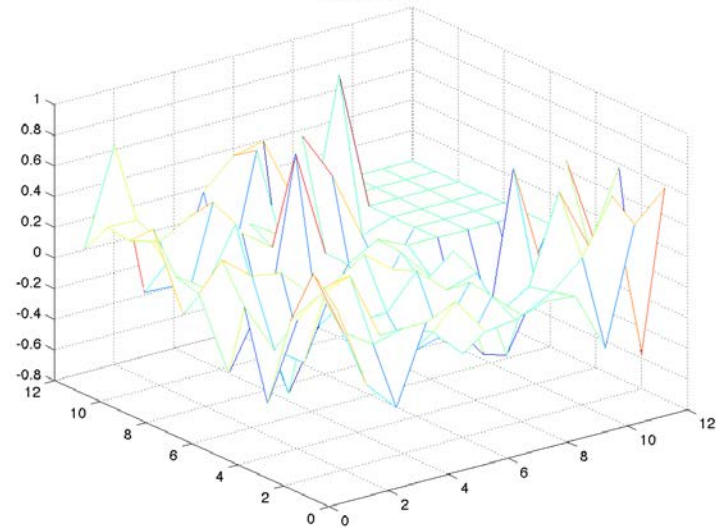
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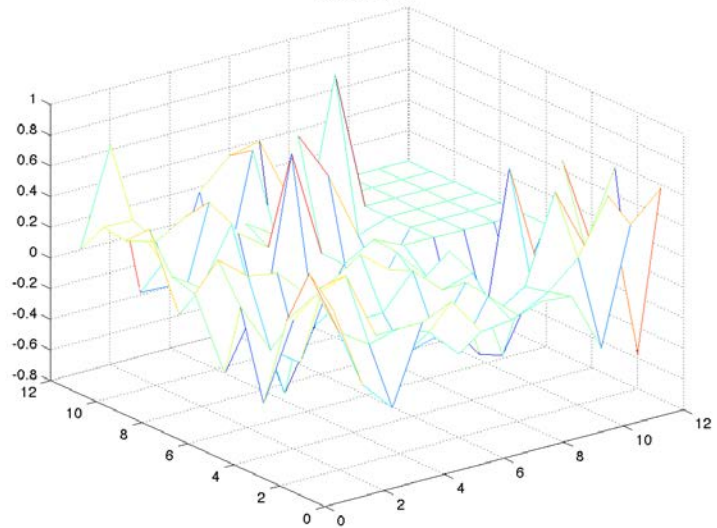
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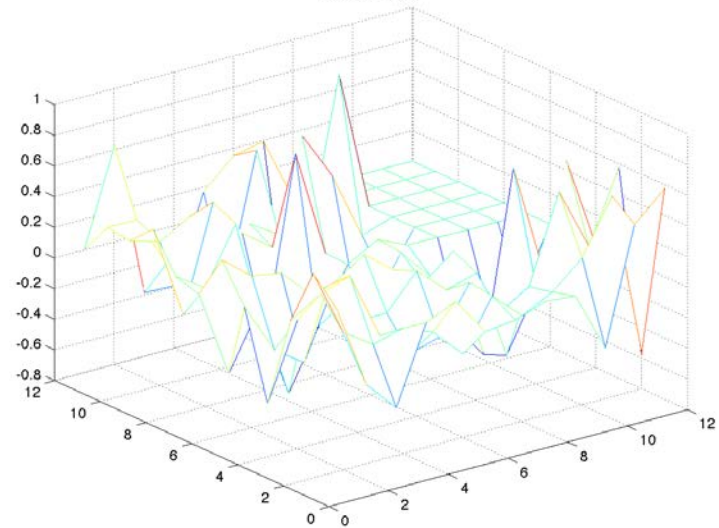
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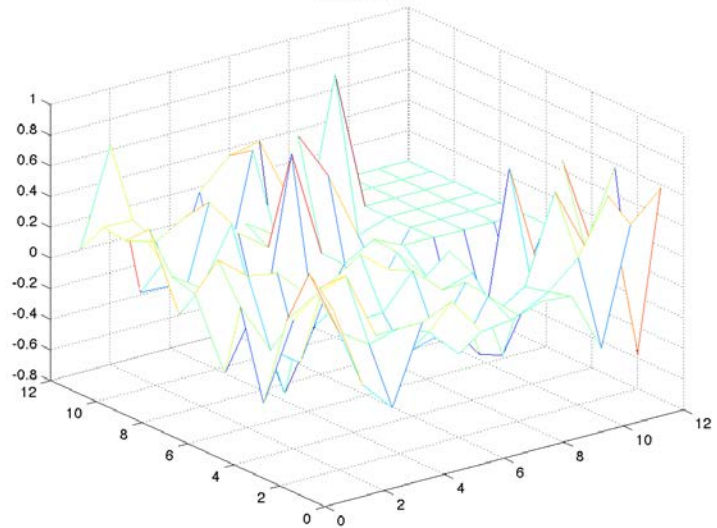
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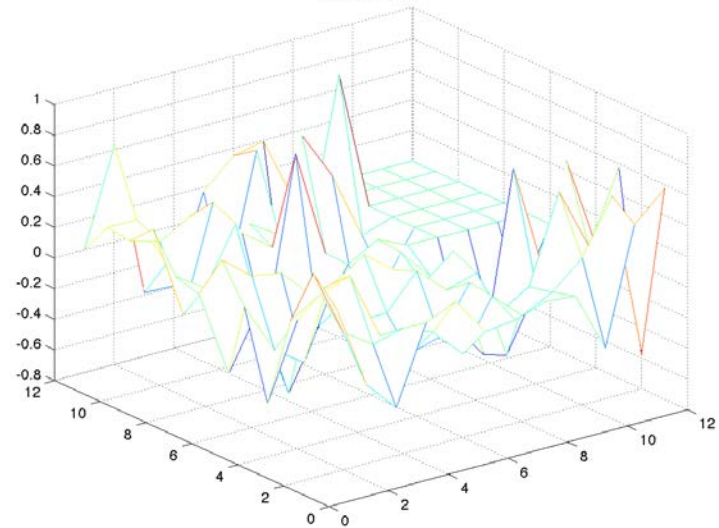
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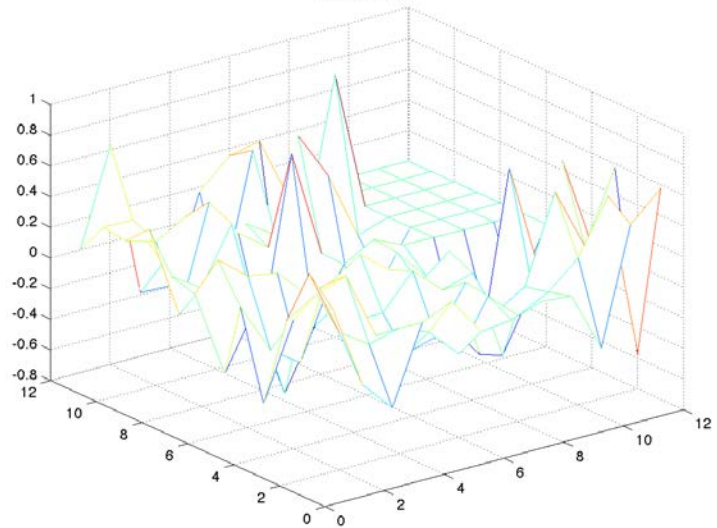
PCA for ID 21



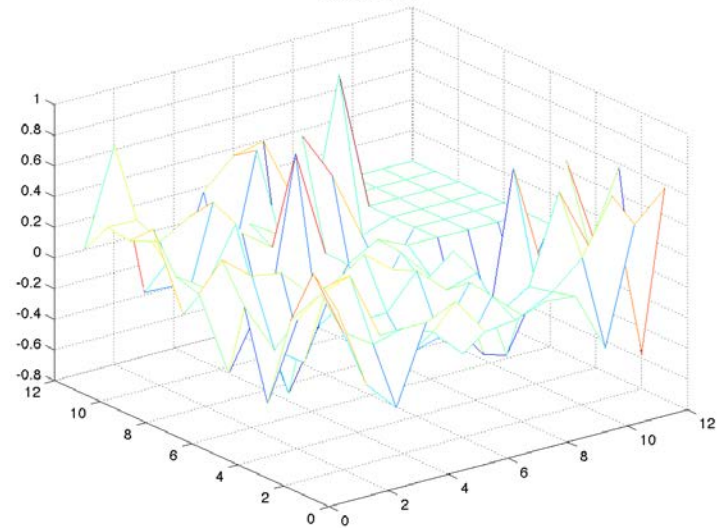
PCA for ID 23



PCA for ID 22

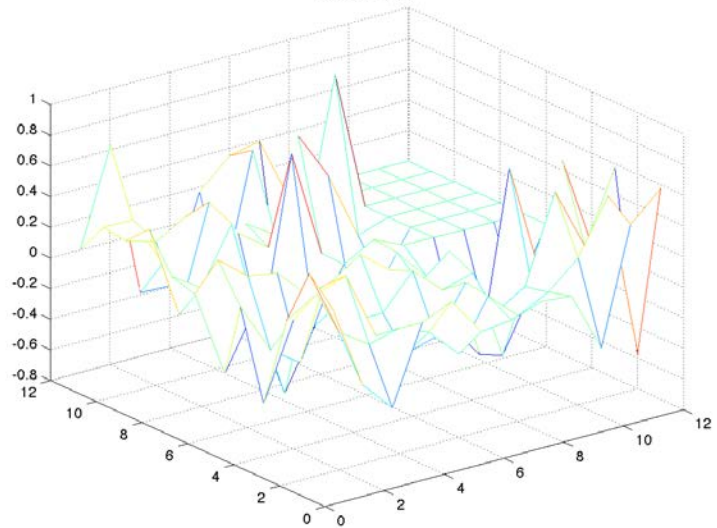


PCA for ID 24

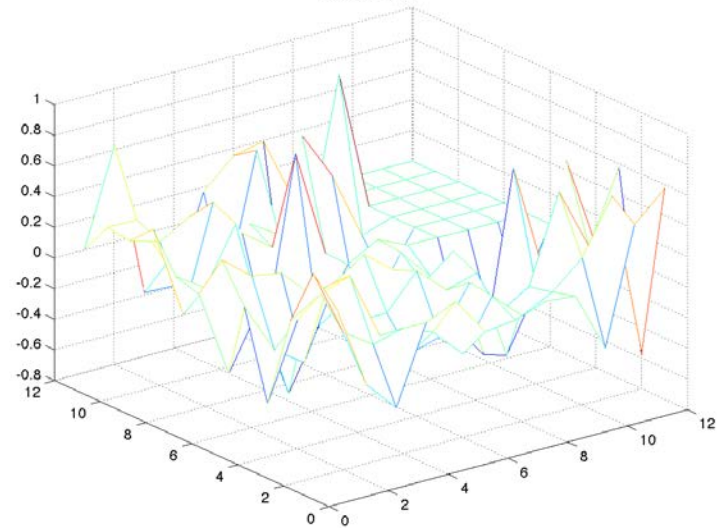




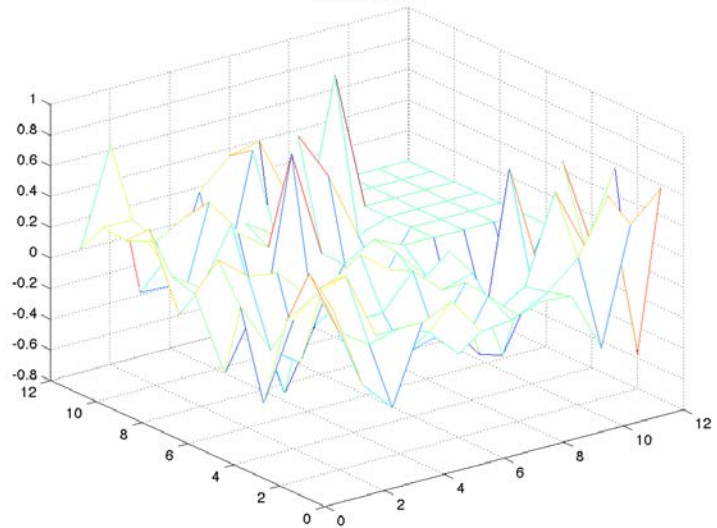
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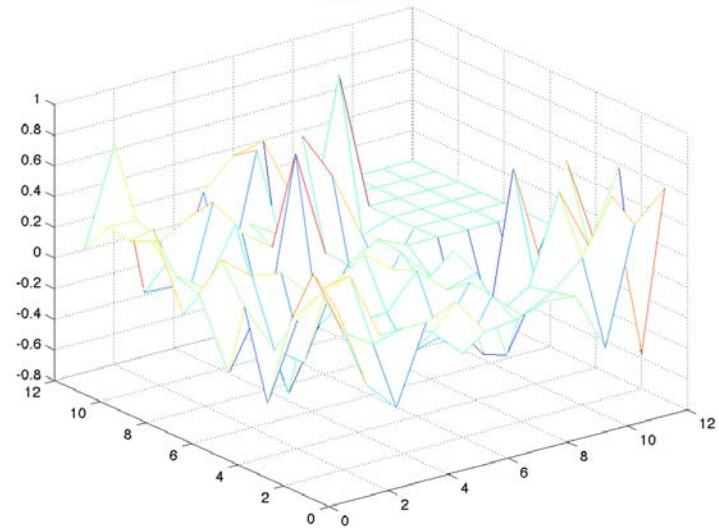
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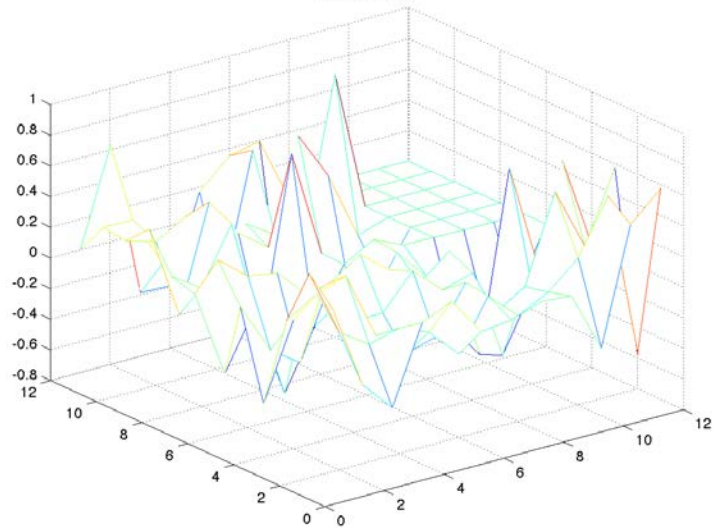
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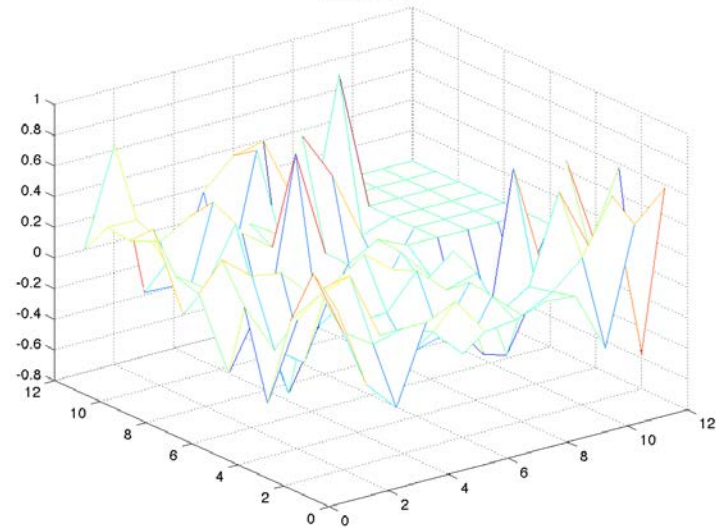
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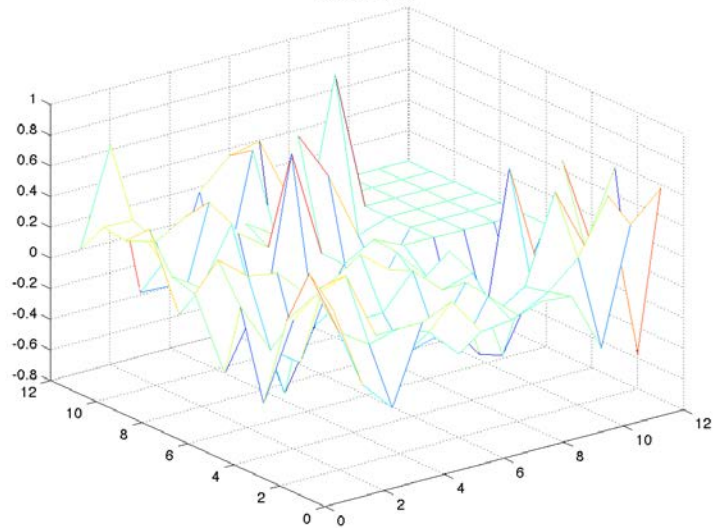
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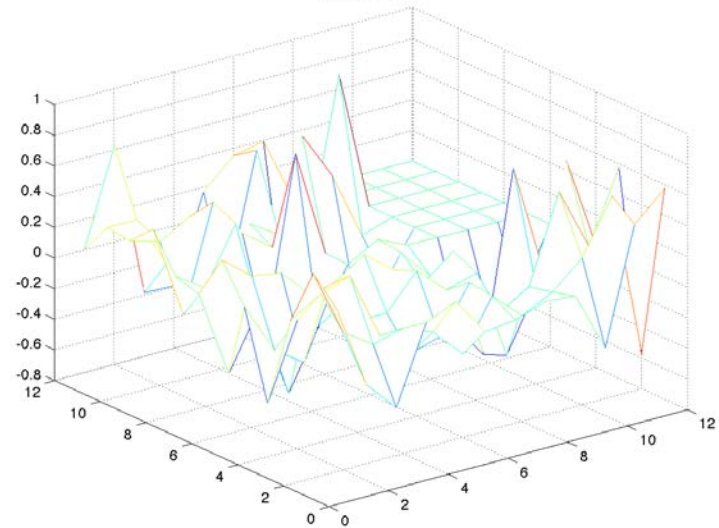
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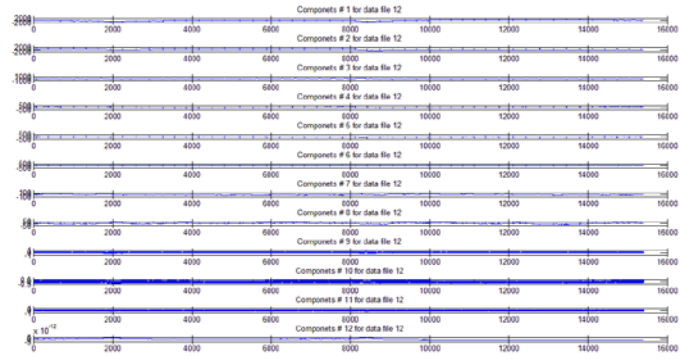
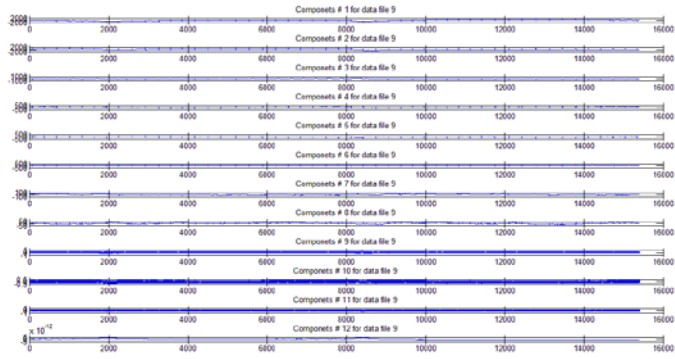
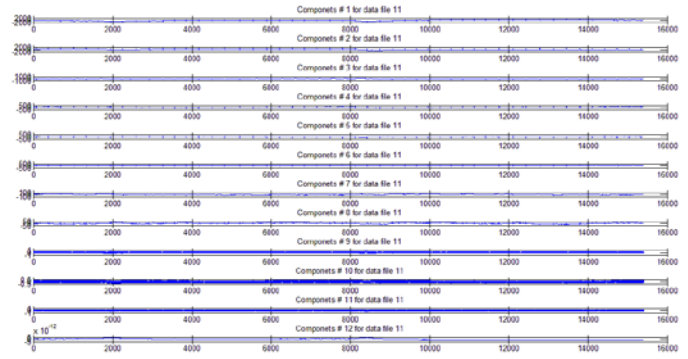
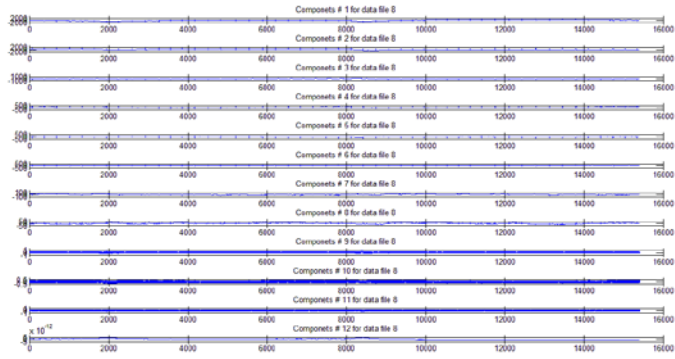
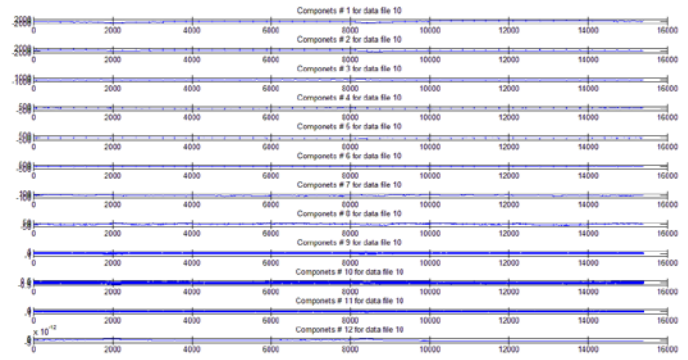
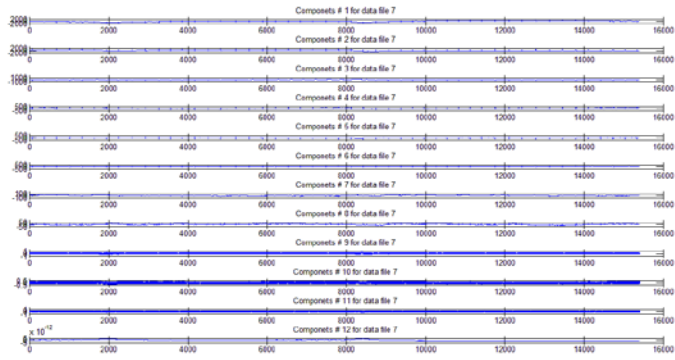
PCA for ID 30



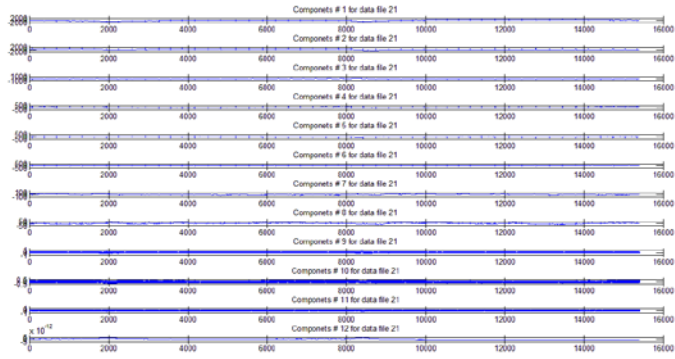
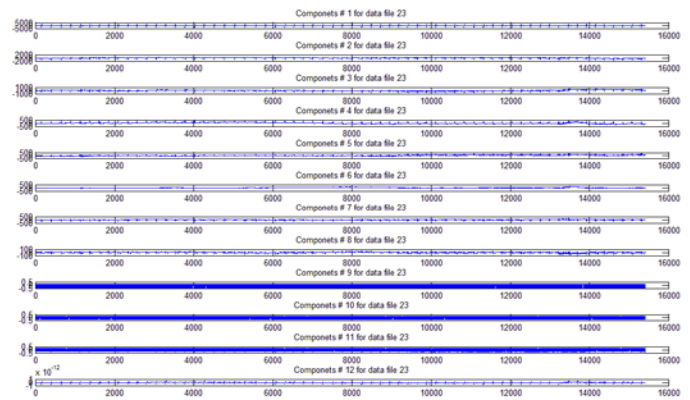
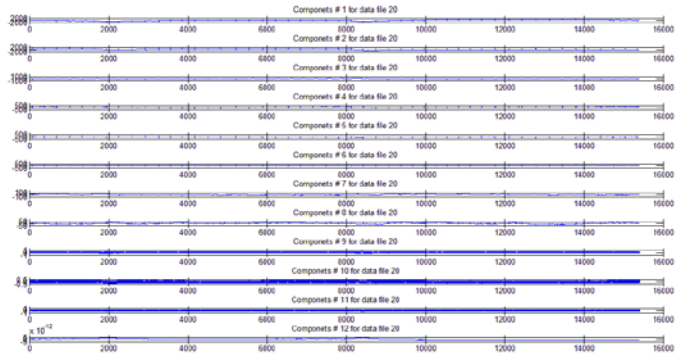
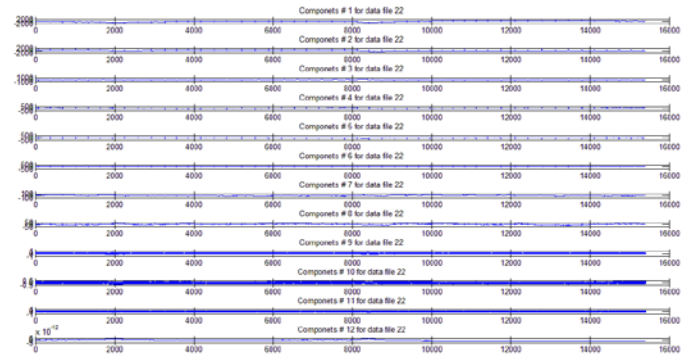
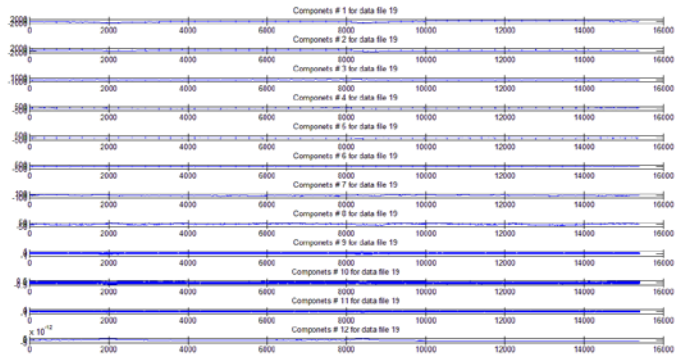
PCA for ID 32

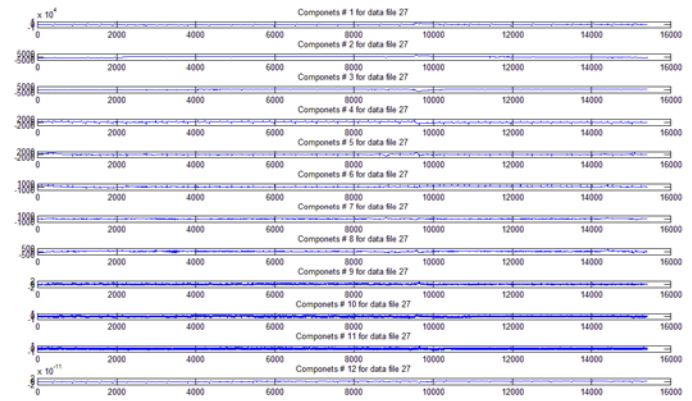
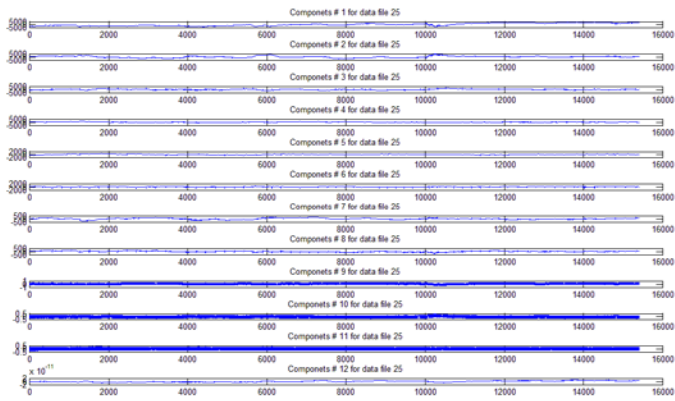
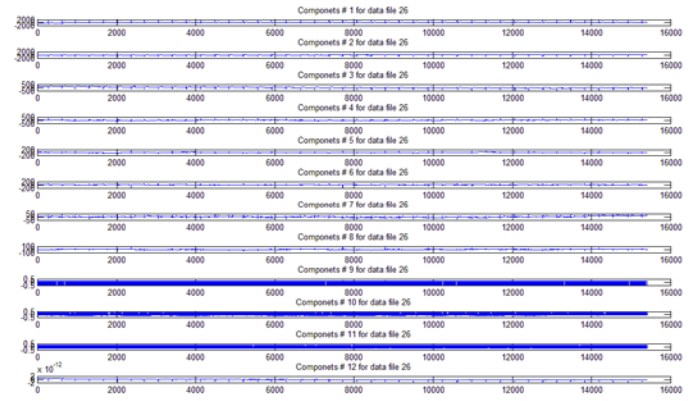
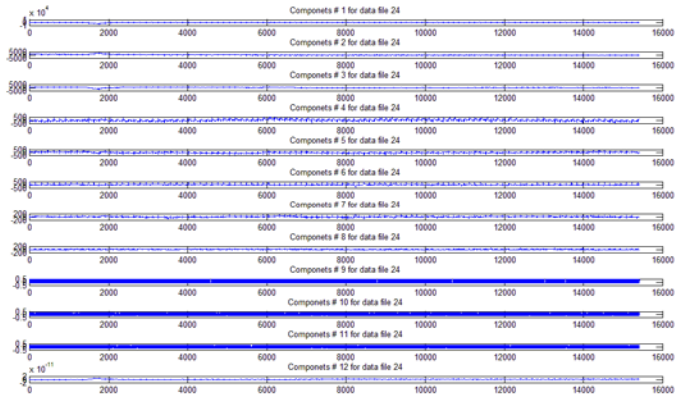


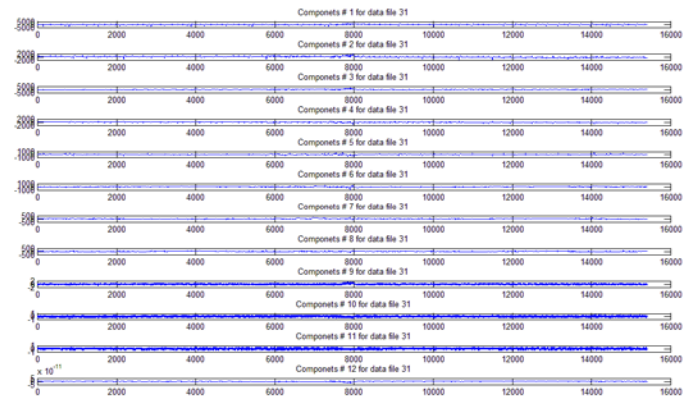
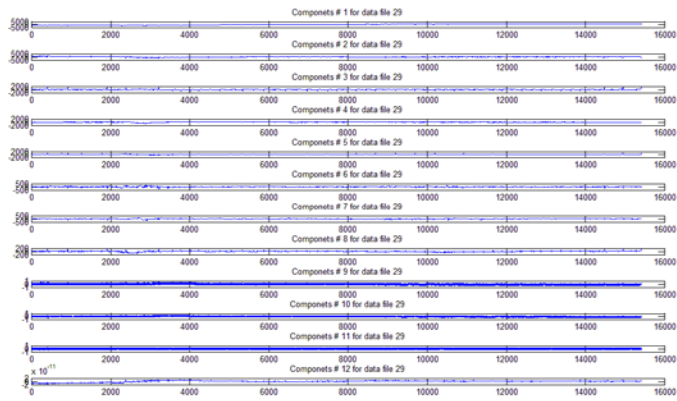
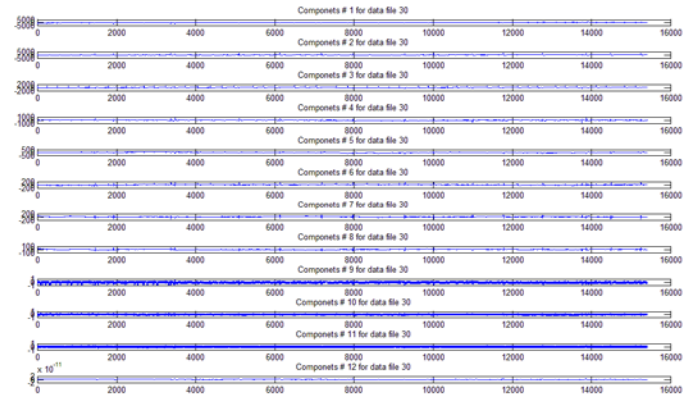
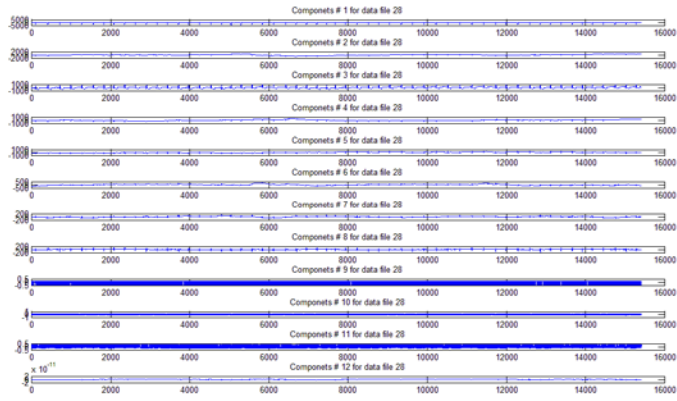














```

function [signals,PC,V] = pca2(data)
PCA2: Perform PCA using SVD.
data - MxN matrix of input data
(M dimensions, N trials)
signals - MxN matrix of projected data
PC - each column is a PC
V - Mx1 matrix of variances
[M,N] = size(data);
subtract off the mean for each dimension
mn = mean(data,2);
data = data - repmat(mn,1,N);
construct the matrix Y
Y = data' / sqrt(N-1);
SVD does it all
[u,S,PC] = svd(Y);
calculate the variances
S = diag(S);
V = S .* S;
project the original data
signals = PC' * data;
P = []
    for i=1:32
        temp1 = ['I',num2str(i),'m.mat']
        load(temp1)
        h=figure;
        set(h,'Position',[1 1 1680 1050]);
        [signals,PC,V] = pca2(val);
        for k = 1: 12
            subplot(12,1,k)
            T = ['Componets # ',num2str(k),' for data file
',num2str(i)];
            plot(signals(k,:))
            title(T)
        end
        name = ['PCA_I',num2str(i)]
        saveas(h,name,'tif'); %name is a string
        close all
        P = [P;PC];
        h = figure
        T = ['PCA for ID ',num2str(i)];
        mesh(PC,'DisplayName','PC')
        title(T)
        name3D = ['data file ',num2str(i)]
        saveas(h,name3D,'png'); %name is a string
        close all
    end

end

```











0.35760846	-0.1388526	-0.2209785	0.16980159	-0.1632934	0.17250398	-0.0599516	0.028468	-0.705939	-0.4647231	0.00526424	6.59E-16
-0.4259356	-0.2766622	0.06317883	0.09020141	0.0986894	-0.0748245	0.01511074	-0.0097808	-0.4875668	0.42731573	-0.54215	9.51E-14
0.22326446	-0.10949	0.43298839	0.26145819	-0.3209627	-0.6783178	-0.3452314	0.002956	-7.39E-05	-1.90E-05	-6.38E-06	2.61E-16
0.22231901	-0.1102528	0.4566976	0.28278908	0.02472875	0.07377323	0.7969603	-0.0931474	0.00016623	0.00010725	1.80E-05	-7.79E-16
0.12607907	-0.055889	0.57302142	0.11092248	0.3824226	0.51894881	-0.4734438	-0.0248825	-0.0001794	-0.0001457	-1.03E-05	7.57E-16
0.14402666	-0.529985	0.2071889	-0.7652775	-0.2513856	0.06756005	0.04260491	0.01486729	-7.03E-05	-2.60E-05	-2.03E-06	-2.66E-16
0.25792398	-0.1747559	-0.1041948	-0.0581218	0.58298687	-0.2853438	0.07199262	0.67986987	0.00025891	0.00019594	-0.0001018	9.13E-17
0.25465753	-0.1876633	-0.2014406	-0.0813352	0.50230558	-0.2725226	-0.0277813	-0.7248358	-0.0001571	-0.0001373	7.30E-05	-1.57E-17
-0.1080423	-0.083259	0.02135951	-0.3784815	0.37950537	0.22230873	-0.1522639	0.04516188	-0.0040846	0.00831608	-0.5344172	0.57735027
-0.3790595	0.26087248	0.14316727	-0.0204868	0.33710412	0.01504487	-0.1838837	0.02200554	0.02364821	0.46626954	-0.260538	-0.5773503
-0.2710172	0.34413151	0.12180776	0.35799476	-0.0424013	-0.2072639	-0.0316197	-0.0231563	0.02773285	0.45795346	0.27387919	0.57735027
0.24339749	-0.0886384	-0.0820389	0.19919468	-0.3583897	-0.1190734	0.16840817	-0.0335669	-0.5639201	0.34766897	-0.5248835	-5.87E-15
0.0813306	-0.2135115	-0.0499996	-0.3683876	0.21073239	0.21447678	-0.060306	0.03396712	-0.5549983	0.33222825	0.54405054	-1.21E-14
-0.3251887	0.30246655	0.13267325	0.16799491	0.14781352	-0.0962793	-0.1078467	0.0001079	-0.6104302	-0.5844251	-0.0038294	7.72E-15
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-0.0748581	0.40982744	0.07735286	-0.3044359	-0.581334	0.4868942	-0.2338976	-0.3131288	-0.0001048	-0.0002226	-0.0001229	-8.26E-16
-0.245072	0.09196999	0.27977522	-0.1801591	-0.0062834	0.18578404	0.88442516	0.0631392	0.00036111	-8.06E-05	0.0001566	1.28E-15
-0.7303124	-0.5218444	-0.2896891	-0.0246306	-0.3230232	-0.0506939	-0.0534687	0.00479623	-2.49E-06	-3.56E-05	-0.0038294	-6.04E-17
-0.0393804	-0.2959746	-0.5225955	0.07775546	0.10421026	-0.0365432	0.01277434	0.01935073	0.0263805	-0.23658	-0.4785019	0.57735027
-0.4793732	-0.0294774	-0.2771307	0.03259883	0.14240716	-0.130795	-0.145442	-0.1183067	0.0374217	0.29639412	-0.4431119	-0.5773503
-0.4399928	0.26649715	0.24546484	-0.0451566	0.0381969	-0.0942519	-0.1582164	-0.1376574	0.0110412	0.5329741	0.03539002	0.57735027
0.25917307	0.16259384	0.39950491	-0.0551242	-0.123313	0.08336033	0.06588146	0.0492548	0.61936508	0.02519834	-0.574961	-1.16E-13
0.20002477	-0.2811494	-0.3841996	0.06162054	0.03316614	0.02867563	0.08493012	0.07792453	0.56528087	0.49882954	0.38204408	8.17E-14
-0.4596629	0.11818227	-0.0162935	-0.0063507	0.09018201	-0.1128086	-0.1515194	-0.1282357	0.54279435	-0.5680255	0.31128349	1.08E-13
-0.0990255	-0.1669894	0.28207485	0.56544339	0.60207942	0.40363281	0.19279865	-0.0206288	0.00028639	-0.0001232	-5.69E-05	1.34E-16
-0.1411092	-0.2788275	0.13081535	0.63649868	-0.6733028	-0.1054715	-0.0603936	-0.1095076	-0.0002027	1.20E-06	7.41E-06	-1.15E-16
-0.1670118	-0.7674788	0.36264236	-0.4706325	-0.0083674	0.09040952	-0.0774191	-0.1258621	-2.97E-05	8.47E-05	1.14E-06	-5.89E-17
-0.335686	-0.0513289	0.07953101	-0.0257578	-0.0728993	-0.0703842	0.21429445	0.90636686	0.00055411	0.00020115	0.00013523	6.17E-16
-0.2521353	0.0888754	-0.0972244	-0.1606833	-0.2082146	0.15241624	0.86077592	-0.2928103	0.00017568	0.0003572	-0.0001643	8.21E-18
-0.1507256	0.12598861	-0.195945	-0.1055551	-0.2799798	0.86126339	-0.2923519	0.07898955	0.00019599	-0.000146	4.65E-05	-1.03E-16
0.37564467	-0.177727	-0.3817998	0.120411	0.20828017	-0.0422432	-0.0179779	0.04940752	0.03123755	-0.3595461	0.3943632	0.57735027
0.53192432	0.09765001	-0.0366284	0.01936487	-0.0596335	-0.2566721	0.07080086	-0.110875	-0.0096857	0.16079365	0.50968604	-0.5773503
0.15627964	0.27537705	0.34517144	-0.1010461	-0.2679137	-0.2144289	0.0887788	-0.1602825	-0.0409233	0.52033974	0.11532284	0.57735027
-0.4537774	0.04003566	0.20922102	-0.0698955	-0.0742643	0.14953873	-0.026402	0.03064608	-0.5612821	-0.1784184	0.60616872	-4.47E-14
0.10979969	-0.2264697	-0.3635054	0.11058501	0.23851009	0.08581276	-0.054219	0.10426417	-0.6235706	0.54043376	-0.1825369	4.53E-14
0.34410004	0.18651089	0.15431259	-0.0408551	-0.1637905	-0.2355644	0.07980308	-0.1356798	-0.5416431	-0.5002164	-0.4130837	3.52E-14
0.0532217	-0.515853	-0.1458916	-0.7537865	-0.3637051	-0.0138902	0.09524541	0.00621951	-9.85E-05	8.77E-05	-1.34E-05	-9.72E-17
0.10318305	-0.0248813	0.33656846	-0.4219851	0.68880268	-0.0096863	-0.3684006	-0.2951644	0.00057554	-0.0004211	0.00012408	-2.31E-16
0.34125604	-0.2689603	0.4141091	0.15596274	0.01228673	0.68679865	0.37274557	-0.0679057	-0.0002467	0.0002772	-0.0001224	2.08E-16
0.19656282	0.1377922	0.25039869	-0.1766783	0.09645083	-0.0262213	-0.0733777	0.91273595	-0.0003141	0.00014385	-5.66E-05	-4.89E-16
0.21581757	0.21209475	-0.1252915	-0.0214812	-0.3842755	0.45478687	-0.7313876	-0.0534084	0.00025588	-0.0002233	6.30E-05	-5.67E-16
-0.0006597	0.62636529	-0.3867499	-0.3922573	0.16794043	0.34877086	0.39081324	-0.0405551	-0.0001168	0.00012045	-7.06E-05	2.27E-16