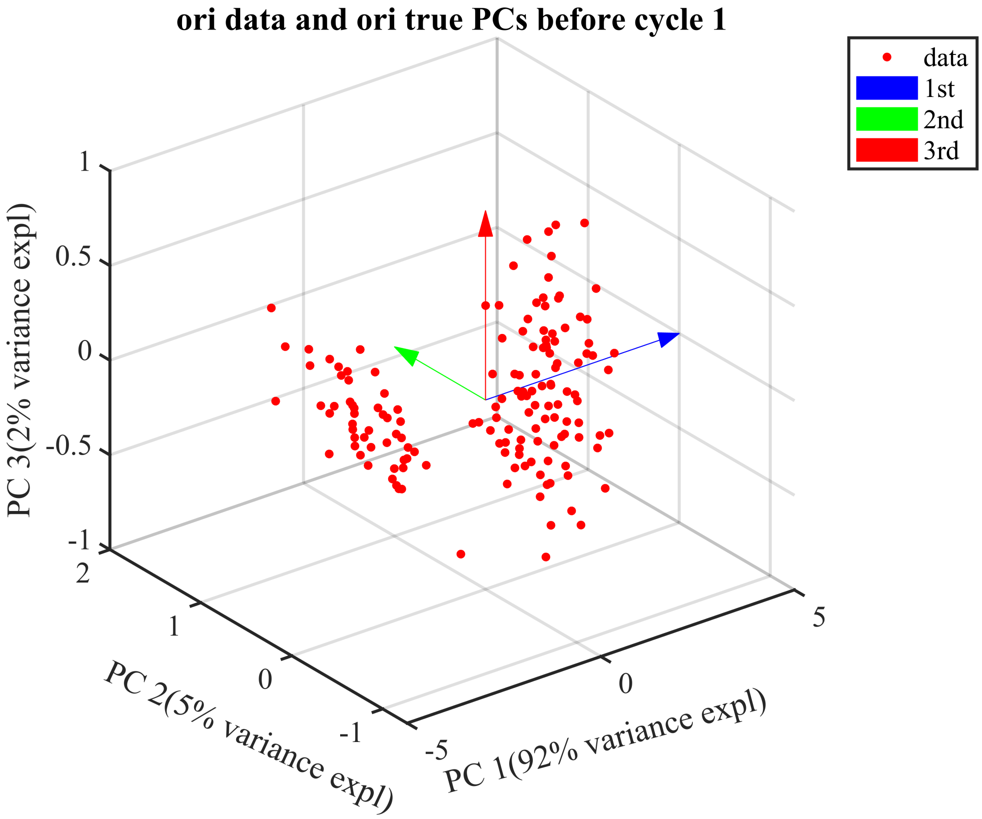
```
clear
format shortG
warning off;
load fisheriris

% Iris data prep
inputs_ori = meas(:,1:4);
inputs = inputs_ori-mean(inputs_ori);

[coeff_real,~,~,~,explained_1,~] = pca(inputs);
o = [0 0 0];
final_all_data =
[inputs;coeff_real(:,1)';coeff_real(:,2)';coeff_real(:,3)'];
[coeff1,~,~,~,explained_real,~] = pca(final_all_data);
Z=final_all_data*coeff1(:,1:3);
%Z = round(Z,4);
coeff_real = round(coeff_real,2);
explained = round(explained_real);


figure;
view(3)
hold on
plot3(Z(1:end-3,1),Z(1:end-3,2),Z(1:end-3,3),'r.','MarkerSize',15)
arrow(o,Z(end-2,:)*5,'Color','b');
arrow(o,Z(end-1,:),'Color','g');
arrow(o,Z(end,:),'Color','r');
xlabel('PC 1(' + string(explained(1))+"% variance expl)")
ylabel('PC 2(' + string(explained(2))+"% variance expl)")
zlabel('PC 3(' + string(explained(3))+"% variance expl)")
xh = get(gca,'XLabel'); % Handle of the x label
set(xh, 'Units', 'Normalized')
pos = get(xh, 'Position');
set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
yh = get(gca,'YLabel'); % Handle of the y label
set(yh, 'Units', 'Normalized')
pos = get(yh, 'Position');
set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
title('ori data and ori true PCs before cycle 1')
legend('data','1st','2nd','3rd')

set(gca, 'FontSize', 15);% Increase font size
set(gca, 'LineWidth', 1.5); % Make lines thicker
set(gca, 'FontName', 'Times New Roman'); % Set preferred font
grid on
hold off
```

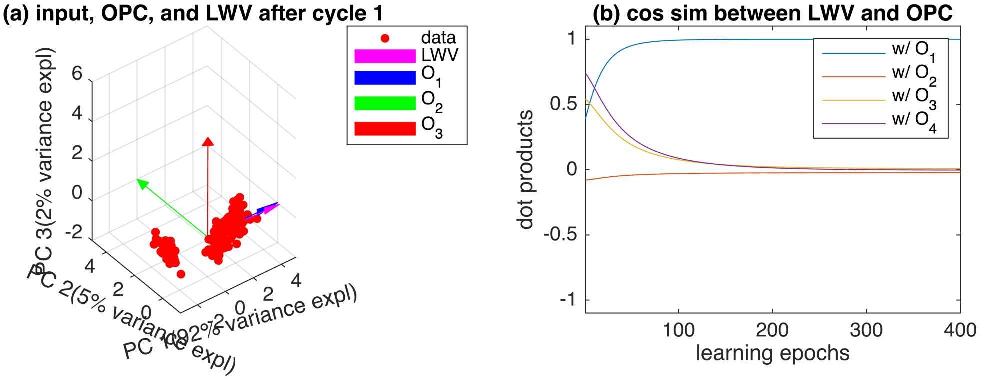


```
% initiate neural weight vectors
SetRNG(1);
dim = size(inputs,2);
n_src = dim;
n_dst = 600;
n_per_src = round(n_src*0.4);
synaptic_weights_mat = randn(n_src,n_dst);
[srcIdx,dstIdx] = ConnectHypergeometric(n_dst, n_src, n_per_src);
index = [srcIdx;dstIdx];
for i = 1:n_dst;
    nonzero_idx = index(2,find(index(1,:) == i));
    zero_idx = setdiff(1:n_src,nonzero_idx);
    synaptic_weights_mat(zero_idx,i) = 0;
end
cells = synaptic_weights_mat; %original
```

```
%cycle 1, find the first PC
cycle = 1;
ori_cycle1_cells = cells;
mean_sum = [];
final_weight = [];
epoch = 400;
```

```
mean1 = [];
for e = 1:epoch;
    imterim_weight = [];
    sampled_data = inputs;
    sampled_data = inputs(randperm(size(inputs, 1)),:);
    mean_sum = [];
    for col = 1:size(sampled_data,1); % loop over all inputs
        lr = 0.0001;
        input1_ori = sampled_data(col,:);% each input
        input1 = input1_ori';
        product = input1'*ori_cycle1_cells;
        signs = sign(product);
        winning_idx = 1:length(product);
        winning_cell = ori_cycle1_cells(:,winning_idx); % the winning cell
set, which may contain more than one winning cell
        update_winner_ori = winning_cell+(signs.*input1-winning_cell)*lr;
        update_winner_norm = update_winner_ori;
        ori_cycle1_cells(:,winning_idx) = update_winner_norm;
    end
     final_weight = [final_weight,normc(ori_cycle1_cells(:,1))];
end

bench_v = ones(size(update_winner_norm,1),1);
id = find(sign(bench_v'*normc(update_winner_norm)) == 1);
center1 = normc(mean(update_winner_norm(:,id),2));
%center1 =
normc(update_winner_norm(:,end));%normc(mean(update_winner_norm,2));
center1 = round(center1,2);

w1_real = normc(center1)'*normc(coeff_real);


final_all_data =
[inputs;center1';coeff_real(:,1)';coeff_real(:,2)';coeff_real(:,3)';];
[coeff_c1,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff_c1(:,1:3);
%Z = round(Z,4);
explained = round(explained);


index = round(linspace(1,epoch,400));
result_c1 = final_weight(:,index);
training_dot = normc(final_weight)'*normc(coeff_real);


figure;
subplot(2,2,1)
view(3)
hold on
```

```
plot3(Z(1:end-4,1),Z(1:end-4,2),Z(1:end-4,3),'r.','MarkerSize',15)
arrow(o,Z(end-3,:)*5,'Color','m');
arrow(o,Z(end-2,:)*5,'Color','b');
arrow(o,Z(end-1,:)*5,'Color','g');
arrow(o,Z(end,:)*5,'Color','r');
title('(a) input, OPC, and LWV after cycle 1')
legend('data','LWV','O_1','O_2','O_3')
xlabel('PC 1(' + string(explained(1))+"% variance expl)")
ylabel('PC 2(' + string(explained(2))+"% variance expl)")
zlabel('PC 3(' + string(explained(3))+"% variance expl)")
xh = get(gca,'XLabel'); % Handle of the x label
set(xh, 'Units', 'Normalized')
pos = get(xh, 'Position');
set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
yh = get(gca,'YLabel'); % Handle of the y label
set(yh, 'Units', 'Normalized')
pos = get(yh, 'Position');
set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
grid on
hold off


subplot(2,2,2)
plot(training_dot)
title('(b) cos sim between LWV and OPC')
legend('w/ O_1','w/ O_2','w/ O_3','w/ O_4','w/ O_5','w/ O_6','w/ O_7','w/
O_8')
xlabel('learning epochs')
ylabel('dot products')
ylim([-1.1 1.1])
xlim([1 400])
```

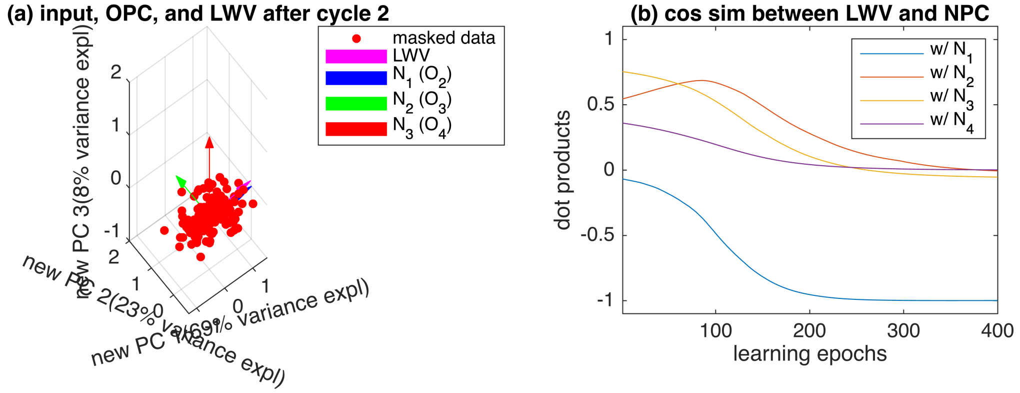


```
%training_dot = array2table(training_dot,'VariableNames', {'pc1',
'pc2','pc3','pc4'})


new_weight = update_winner_norm-mean(update_winner_norm,2);
new_weight = normc(new_weight)';
[idx,C,sumd,D] = kmeans(new_weight,2);
%[C,winner_idx] = SOM(new_weight);
[coeff_c,~,~,~,explained,~] = pca([new_weight;C]);


Z_c1 = [new_weight;C]*coeff_c(:,1:3);

% figure;
% view(3)
% title("clustering learned weight vectors")
%
plot3(Z_c1(1:end-2,1),Z_c1(1:end-2,2),Z_c1(1:end-2,3),'r*','MarkerSize',20)
% arrow(o,Z_c1(end-1,:),'Color','b');
% arrow(o,Z_c1(end,:),'Color','b');
% xlim([-1 1])
% ylim([-1 1])
% zlim([-1 1])
%
%
% true_PC_var = var(inputs*normc(coeff_real(:,1)))
% esti_PC_var = var(inputs*normc(center1))
```

```
%cycle 2 input masking

norm_vec_c1 = normc(center1);
%norm_vec_c1 = coeff_real(:,1);
c2_inputs_set = (inputs'-norm_vec_c1*(inputs*norm_vec_c1./
norm(norm_vec_c1))')';
c2_inputs_set = c2_inputs_set-mean(c2_inputs_set); % new data


[coeff_c2,~,~,~,explained,~] = pca(c2_inputs_set);
o = [0 0 0];

final_all_data =
[c2_inputs_set;coeff_c2(:,1)';coeff_c2(:,2)';coeff_c2(:,3)'];
[coeff,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff(:,1:3);
explained = round(explained);

normc(coeff_c2(:,1))'*normc(coeff_real); %shift-match
normc(coeff_c2(:,2))'*normc(coeff_real);
normc(coeff_c2(:,3))'*normc(coeff_real);

% figure;
% view(3)
% hold on
% plot3(Z(1:end-3,1),Z(1:end-3,2),Z(1:end-3,3),'r.','MarkerSize',15)
% arrow(o,Z(end-2,:)*5,'Color','b');
% arrow(o,Z(end-1,:)*5,'Color','g');
% arrow(o,Z(end,:)*5,'Color','r');
% legend('masked data','old PC2,new PC1','old PC3,new PC2','old PC4,new
PC3')
%
% xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
% ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
% zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
% xh = get(gca,'XLabel'); % Handle of the x label
% set(xh, 'Units', 'Normalized')
% pos = get(xh, 'Position');
% set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
% yh = get(gca,'YLabel'); % Handle of the y label
% set(yh, 'Units', 'Normalized')
% pos = get(yh, 'Position');
% set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
% grid on
% hold off
```

```
%cycle 2, find the second PC
cycle = 2;
ori_cycle2_cells = cells;
mean_sum = [];
final_weight = [];
epoch = 400;

sum1 = [];
for e = 1:epoch;
    sampled_data = c2_inputs_set;
    sampled_data = c2_inputs_set(randperm(size(c2_inputs_set, 1)),:);
    for col = 1:size(sampled_data,1); % loop over all inputs
        lr = 0.0001;
        input1_ori = sampled_data(col,:);% each input
        input1 = input1_ori';
        product = input1'*ori_cycle2_cells;
        signs = sign(product);
        sum1 = [sum1;sum(signs)];
        winning_idx = 1:length(product);
        %winning_idx = winning_idx(randperm(length(winning_idx)));
        winning_cell = ori_cycle2_cells(:,winning_idx); % the winning cell
set, which may contain more than one winning cell
        update_winner_ori = winning_cell+(signs.*input1-winning_cell)*lr;
        update_winner_norm = update_winner_ori;
        ori_cycle2_cells(:,winning_idx) = update_winner_norm;
    end

    if e>epoch*0.5;
        mean_sum = [mean_sum,mean(update_winner_norm,2)];
    end
     %final_weight = [final_weight,mean(update_winner_norm,2)];
     final_weight = [final_weight,normc(ori_cycle2_cells(:,1))];
end



bench_v = ones(size(update_winner_norm,1),1);
id = find(sign(bench_v'*normc(update_winner_norm)) == 1);
center2 = normc(mean(update_winner_norm(:,id),2));
%center2 =
normc(update_winner_norm(:,end));%normc(mean(update_winner_norm,2));
center2 = round(center2,2);

w2_real = normc(center2)'*normc(coeff_real);
w2_c2 = normc(center2)'*normc(coeff_c2);


final_all_data =
[c2_inputs_set;center2';coeff_c2(:,1)';coeff_c2(:,2)';coeff_c2(:,3)';];
```

```
[coeff_c,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff_c(:,1:3);
explained = round(explained);

index = round(linspace(1,epoch,400));
result_c2 = final_weight(:,index);
training_dot2 = normc(final_weight)'*normc(coeff_c2);

figure;
subplot(2,2,1)
view(3)
hold on
plot3(Z(1:end-4,1),Z(1:end-4,2),Z(1:end-4,3),'r.','MarkerSize',15)
arrow(o,Z(end-3,:)*1.5,'Color','m');
arrow(o,Z(end-2,:)*1.5,'Color','b');
arrow(o,Z(end-1,:)*1.5,'Color','g');
arrow(o,Z(end,:)*1.5,'Color','r');
title('(a) input, OPC, and LWV after cycle 2')
legend('masked data','LWV','N_1 (O_2)','N_2 (O_3)','N_3 (O_4)')
xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
xh = get(gca,'XLabel'); % Handle of the x label
set(xh, 'Units', 'Normalized')
pos = get(xh, 'Position');
set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
yh = get(gca,'YLabel'); % Handle of the y label
set(yh, 'Units', 'Normalized')
pos = get(yh, 'Position');
set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
grid on
hold off


subplot(2,2,2)
plot(training_dot2)
title('(b) cos sim between LWV and NPC')
legend('w/ N_1','w/ N_2','w/ N_3','w/ N_4','w/ N_5','w/ N_6','w/ N_7','w/
N_8')
xlabel('learning epochs')
ylabel('dot products')
ylim([-1.1 1.1])
xlim([1 400])
```



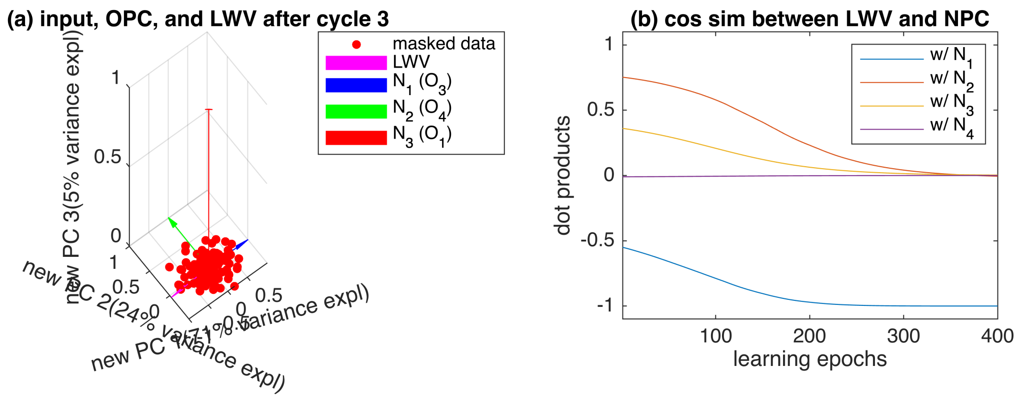
```
new_weight = update_winner_norm-mean(update_winner_norm,2);
new_weight = normc(new_weight)';
[idx,C,sumd,D] = kmeans(new_weight,2);
%[C,winner_idx] = SOM(new_weight);
[coeff_c,~,~,~,explained,~] = pca([new_weight;C]);


Z_c2 = [new_weight;C]*coeff_c(:,1:3);

% figure;
% view(3)
%
plot3(Z_c2(1:end-2,1),Z_c2(1:end-2,2),Z_c2(1:end-2,3),'r*','MarkerSize',20)
% arrow(o,Z_c2(end-1,:),'Color','b');
% arrow(o,Z_c2(end,:),'Color','b');
% xlim([-1 1])
% ylim([-1 1])
% zlim([-1 1])
% title("clustering learned weight vectors")
```

```
%cycle 3 input masking
norm_vec_c2 = normc(center2);
c3_inputs_set = (c2_inputs_set'-norm_vec_c2*(c2_inputs_set*norm_vec_c2./
norm(norm_vec_c2))')';
```

```
c3_inputs_set = c3_inputs_set-mean(c3_inputs_set); % new data

[coeff_c3,~,~,~,explained,~] = pca(c3_inputs_set);
o = [0 0 0];
explained = round(explained);
final_all_data =
[c3_inputs_set;coeff_c3(:,1)';coeff_c3(:,2)';coeff_c3(:,3)'];
[coeff,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff(:,1:3);

normc(coeff_c3(:,1))'*normc(coeff_real);
normc(coeff_c3(:,2))'*normc(coeff_real);
normc(coeff_c3(:,3))'*normc(coeff_real);

% figure;
% view(3)
% hold on
% plot3(Z(1:end-3,1),Z(1:end-3,2),Z(1:end-3,3),'r.','MarkerSize',15)
% arrow(o,Z(end-2,:),'Color','b');
% arrow(o,Z(end-1,:),'Color','g');
% arrow(o,Z(end,:),'Color','r');
% title('(a) input, OPC, and LWV after cycle 3')
% legend('masked data','LWV','N_1 (O_3)','N_2 (O_4)','N_3 (O_1)')
% xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
% ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
% zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
% xh = get(gca,'XLabel'); % Handle of the x label
% set(xh, 'Units', 'Normalized')
% pos = get(xh, 'Position');
% set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
% yh = get(gca,'YLabel'); % Handle of the y label
% set(yh, 'Units', 'Normalized')
% pos = get(yh, 'Position');
% set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
% grid on
% hold off


%cycle 3, find the 3rd PC
cycle = 3;
ori_cycle3_cells = cells;
mean_sum = [];
final_weight = [];
epoch = 400;


for e = 1:epoch;
    sampled_data = c3_inputs_set;
    sampled_data = c3_inputs_set(randperm(size(c3_inputs_set, 1)),:);
    for col = 1:size(sampled_data,1); % loop over all inputs
```

```
        lr = 0.0001;
        input1_ori = sampled_data(col,:);% each input
        input1 = input1_ori';
        product = input1'*ori_cycle3_cells;
        signs = sign(product);
        winning_idx = 1:length(product);
        %winning_idx = winning_idx(randperm(length(winning_idx)));
        winning_cell = ori_cycle3_cells(:,winning_idx); % the winning cell
set, which may contain more than one winning cell
        update_winner_ori = winning_cell+(signs.*input1-winning_cell)*lr;
        update_winner_norm = update_winner_ori;
        ori_cycle3_cells(:,winning_idx) = update_winner_norm;
    end

    if e>epoch*0.5;
        mean_sum = [mean_sum,mean(update_winner_norm,2)];
    end
     %final_weight = [final_weight,mean(update_winner_norm,2)];
     final_weight = [final_weight,normc(ori_cycle3_cells(:,1))];
end



bench_v = ones(size(update_winner_norm,1),1);
id = find(sign(bench_v'*normc(update_winner_norm)) == 1);
center3 = normc(mean(update_winner_norm(:,id),2));
center3 = round(center3,2);
w3_real = normc(center3)'*normc(coeff_real);
w3_c3 = normc(center3)'*normc(coeff_c3);


final_all_data =
[c3_inputs_set;center3';coeff_c3(:,1)';coeff_c3(:,2)';coeff_c3(:,3)';];
[coeff_c,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff_c(:,1:3);
explained = round(explained);

index = round(linspace(1,epoch,400));
result_c3 = final_weight(:,index);
training_dot3 = normc(final_weight)'*normc(coeff_c3);

figure;
subplot(2,2,1)
view(3)
hold on
plot3(Z(1:end-4,1),Z(1:end-4,2),Z(1:end-4,3),'r.','MarkerSize',15)
arrow(o,Z(end-3,:),'Color','m');
arrow(o,Z(end-2,:),'Color','b');
arrow(o,Z(end-1,:),'Color','g');
arrow(o,Z(end,:),'Color','r');
```

```
title('(a) input, OPC, and LWV after cycle 3')
legend('masked data','LWV','N_1 (O_3)','N_2 (O_4)','N_3 (O_1)')
xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
xh = get(gca,'XLabel'); % Handle of the x label
set(xh, 'Units', 'Normalized')
pos = get(xh, 'Position');
set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
yh = get(gca,'YLabel'); % Handle of the y label
set(yh, 'Units', 'Normalized')
pos = get(yh, 'Position');
set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
grid on
hold off

subplot(2,2,2)
plot(training_dot3)
title('(b) cos sim between LWV and NPC')
legend('w/ N_1','w/ N_2','w/ N_3','w/ N_4','w/ N_5','w/ N_6','w/ N_7','w/
N_8')
xlabel('learning epochs')
ylabel('dot products')
ylim([-1.1 1.1])
xlim([1 400])
```

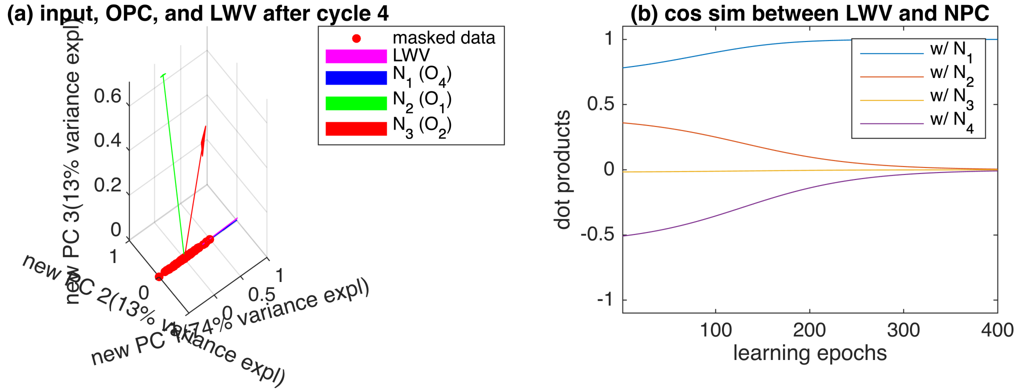


```
true_3PC = coeff_real(:,1:3);
estimated_3PC = [center1,center2,center3];
true_PC_var = var(inputs*normc(true_3PC))./sum(var(inputs*normc(true_3PC)));
estimated_PC_var = var(inputs*normc(estimated_3PC))./
sum(var(inputs*normc(estimated_3PC)));
normc(update_winner_norm)'*normc(coeff_c3(:,1));


new_weight = update_winner_norm-mean(update_winner_norm,2);
new_weight = normc(new_weight)';
[idx,C,sumd,D] = kmeans(new_weight,2);
%[C,winner_idx] = SOM(new_weight);
[coeff_c,~,~,~,explained,~] = pca([new_weight;C]);


Z_c3 = [new_weight;C]*coeff_c(:,1:3);

% figure;
% view(3)
%
plot3(Z_c3(1:end-2,1),Z_c3(1:end-2,2),Z_c3(1:end-2,3),'r*','MarkerSize',20)
% arrow(o,Z_c3(end-1,:),'Color','b');
% arrow(o,Z_c3(end,:),'Color','b');
% xlim([-1 1])
% ylim([-1 1])
% zlim([-1 1])
% title("clustering learned weight vectors")
```

```
%cycle 4 input masking
norm_vec_c3 = normc(center3);
%norm_vec_c3 = coeff_real(:,3);
c4_inputs_set = (c3_inputs_set'-norm_vec_c3*(c3_inputs_set*norm_vec_c3./
norm(norm_vec_c3))')';
c4_inputs_set = c4_inputs_set-mean(c4_inputs_set); % new data


[coeff_c4,~,~,~,explained,~] = pca(c4_inputs_set);
o = [0 0 0];

final_all_data =
[c4_inputs_set;coeff_c4(:,1)';coeff_c4(:,2)';coeff_c4(:,3)'];
[coeff,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff(:,1:3);

normc(coeff_c4(:,1))'*normc(coeff_real);
normc(coeff_c4(:,2))'*normc(coeff_real);
normc(coeff_c4(:,3))'*normc(coeff_real);
explained = round(explained);
```

```
% figure;
% view(3)
% hold on
% plot3(Z(1:end-3,1),Z(1:end-3,2),Z(1:end-3,3),'r.','MarkerSize',15)
% arrow(o,Z(end-2,:),'Color','b');
% arrow(o,Z(end-1,:),'Color','g');
% arrow(o,Z(end,:),'Color','r');
% title('transformed data and new true PCs before cycle 4')
% legend('data','old PC4,new PC1','old PC1,new PC2','old PC2,new PC3')
% xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
% ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
% zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
% xh = get(gca,'XLabel'); % Handle of the x label
% set(xh, 'Units', 'Normalized')
% pos = get(xh, 'Position');
% set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
% yh = get(gca,'YLabel'); % Handle of the y label
% set(yh, 'Units', 'Normalized')
% pos = get(yh, 'Position');
% set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
% grid on
% hold off



%cycle 4, find the 4 PC
cycle = 4;
ori_cycle4_cells = cells;
final_weight = [];
epoch = 400;

mean1 = [];
for e = 1:epoch;
    sampled_data = c4_inputs_set;
    sampled_data = c4_inputs_set(randperm(size(c4_inputs_set, 1)),:);
    mean_sum = [];
    for col = 1:size(sampled_data,1); % loop over all inputs
        lr = 0.0001;
        input1_ori = sampled_data(col,:);% each input
        %input1 = normr(input1_ori)';
        input1 = input1_ori';
        product = input1'*ori_cycle4_cells;
        signs = sign(product);
        sign2 = sign(input1'*ori_cycle4_cells(:,1));
        winning_idx = 1:length(product);
        %winning_idx = winning_idx(randperm(length(winning_idx)));
        winning_cell = ori_cycle4_cells(:,winning_idx); % the winning cell
set, which may contain more than one winning cell
        update_winner_ori = winning_cell+(signs.*input1-winning_cell)*lr;
        update_winner_norm = update_winner_ori;
        mean_sum = [mean_sum,sign2.*input1];
        ori_cycle4_cells(:,winning_idx) = update_winner_norm;
    end
    %mean1 = [mean1,normc(mean(mean_sum,2))];
    mean1 = [mean1,mean(mean_sum,2)];
    final_weight = [final_weight,normc(ori_cycle4_cells(:,1))];
end



bench_v = ones(size(update_winner_norm,1),1);
id = find(sign(bench_v'*normc(update_winner_norm)) == 1);
[max_align,id] = max(abs(normc(update_winner_norm)'*coeff_real(:,4)));
center4 = normc(mean(update_winner_norm(:,id),2));
%center4 = normc(mean(update_winner_norm(:,id),2));
center4 = round(center4,2);
w4_real = normc(center4)'*normc(coeff_real);
w4_c4 = normc(center4)'*normc(coeff_c4);


final_all_data =
[c4_inputs_set;center4';coeff_c4(:,1)';coeff_c4(:,2)';coeff_c4(:,3)';];
[coeff_c,~,~,~,explained,~] = pca(final_all_data);
Z=final_all_data*coeff_c(:,1:3);
explained = round(explained);

index = round(linspace(1,epoch,20));
result_c4 = final_weight(:,index);
training_dot4 = normc(final_weight)'*normc(coeff_c4);

ori_acute_percentage = sum(sign(mean1(:,end)'*inputs') == 1)./
size(inputs,1);
after_acute_percentage = sum(sign(mean1(:,end)'*mean_sum) == 1)./
size(inputs,1);

figure;
subplot(2,2,1)
view(3)
hold on
plot3(Z(1:end-4,1),Z(1:end-4,2),Z(1:end-4,3),'r.','MarkerSize',15)
arrow(o,Z(end-3,:),'Color','m');
arrow(o,Z(end-2,:),'Color','b');
arrow(o,Z(end-1,:),'Color','g');
arrow(o,Z(end,:),'Color','r');
title('(a) input, OPC, and LWV after cycle 4')
legend('masked data','LWV','N_1 (O_4)','N_2 (O_1)','N_3 (O_2)')
xlabel('new PC 1(' + string(explained(1))+"% variance expl)")
ylabel('new PC 2(' + string(explained(2))+"% variance expl)")
zlabel('new PC 3(' + string(explained(3))+"% variance expl)")
```

```
xh = get(gca,'XLabel'); % Handle of the x label
set(xh, 'Units', 'Normalized')
pos = get(xh, 'Position');
set(xh, 'Position',pos.*[1,-0.05,1],'Rotation',15)
yh = get(gca,'YLabel'); % Handle of the y label
set(yh, 'Units', 'Normalized')
pos = get(yh, 'Position');
set(yh, 'Position',pos.*[1,-0.07,1],'Rotation',-25)
grid on
hold off



subplot(2,2,2)
plot(training_dot4)
title('(b) cos sim between LWV and NPC')
legend('w/ N_1','w/ N_2','w/ N_3','w/ N_4','w/ N_5','w/ N_6','w/ N_7','w/
N_8')
xlabel('learning epochs')
ylabel('dot products')
ylim([-1.1 1.1])
xlim([1 400])
```



(a) input, OPC, and LWV after cycle 4

(b) cos sim between LWV and NPC

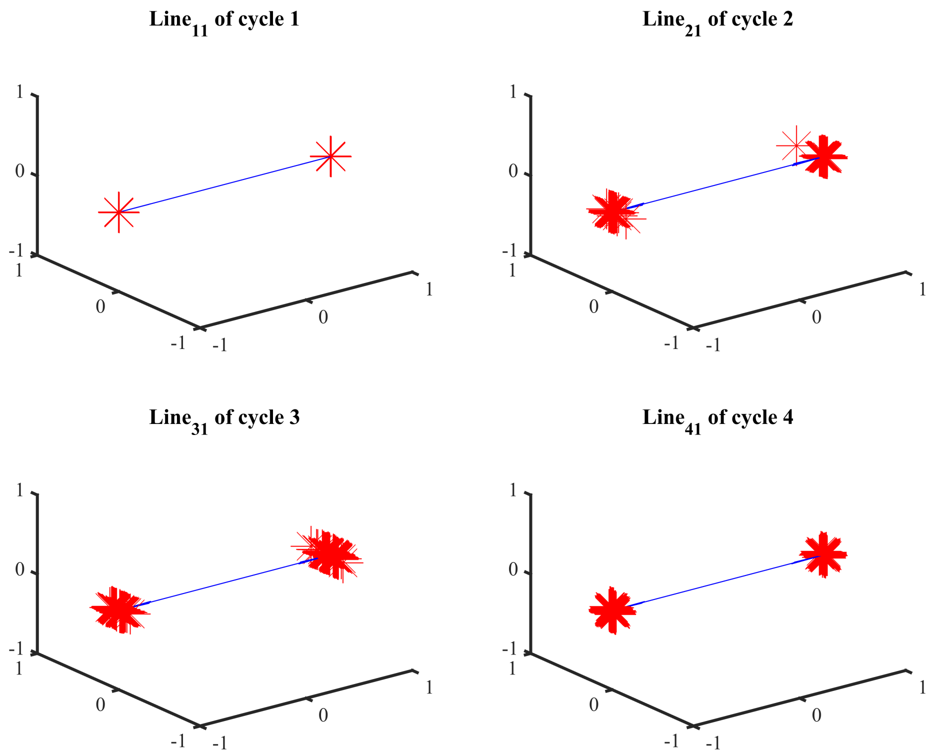
```
true_PC = coeff_real(:,1:4);
estimated_PC = [center1,center2,center3,center4];
estimated_PC = [center1,center2,center3,normr(C(1,:))'];
```

```
true_PC_var = var(inputs*normc(true_PC))./sum(var(inputs*normc(true_PC)));
estimated_PC_var = var(inputs*normc(estimated_PC))./
sum(var(inputs*normc(estimated_PC)));

a = normc(update_winner_norm);
idx = find(abs(normc(update_winner_norm)'*normc(coeff_c4(:,1)))>0.98);
```

```
new_weight = update_winner_norm-mean(update_winner_norm,2);
new_weight = normc(new_weight)';
[idx,C,sumd,D] = kmeans(new_weight,2);
%[C,winner_idx] = SOM(new_weight);
[coeff_c,~,~,~,explained,~] = pca([new_weight;C]);
normr(C(2,:))*normc(coeff_c4(:,1));

Z_c4 = [new_weight;C]*coeff_c(:,1:3);


% figure;
% view(3)
%
plot3(Z_c4(1:end-2,1),Z_c4(1:end-2,2),Z_c4(1:end-2,3),'r*','MarkerSize',20)
% arrow(o,Z_c4(end-1,:),'Color','b');
% arrow(o,Z_c4(end,:),'Color','b');
% xlim([-1 1])
% ylim([-1 1])
% zlim([-1 1])
% title("clustering learned weight vectors")


estimated_PC = [center1,center2,center3,normr(C(1,:))'];


true_PC_var = explained_real'./100;%var(inputs*normc(true_PC))./
sum(var(inputs*normc(true_PC)))
AIME_var = var(inputs*normc(estimated_PC))./
sum(var(inputs*normc(estimated_PC)));
true_PC_var_accum = cumsum(true_PC_var);
AIME_accum = cumsum(AIME_var);
```

```
figure;
subplot(2,2,1)
view(3)
plot3(Z_c1(1:end-2,1),Z_c1(1:end-2,2),Z_c1(1:end-2,3),'r*','MarkerSize',20)
arrow(o,Z_c1(end-1,:),'Color','b');
arrow(o,Z_c1(end,:),'Color','b');
xlim([-1 1])
ylim([-1 1])
```

```
zlim([-1 1])
title('Line_{11} of cycle 1')
set(gca, 'FontSize', 10); % Increase font size
set(gca, 'LineWidth', 1.5); % Make lines thicker
set(gca, 'FontName', 'Times New Roman'); % Set preferred font

subplot(2,2,2)
view(3)
plot3(Z_c2(1:end-2,1),Z_c2(1:end-2,2),Z_c2(1:end-2,3),'r*','MarkerSize',20)
arrow(o,Z_c2(end-1,:),'Color','b');
arrow(o,Z_c2(end,:),'Color','b');
xlim([-1 1])
ylim([-1 1])
zlim([-1 1])
title('Line_{21} of cycle 2')
set(gca, 'FontSize', 10);% Increase font size
set(gca, 'LineWidth', 1.5); % Make lines thicker
set(gca, 'FontName', 'Times New Roman'); % Set preferred font

subplot(2,2,3)
view(3)
plot3(Z_c3(1:end-2,1),Z_c3(1:end-2,2),Z_c3(1:end-2,3),'r*','MarkerSize',20)
arrow(o,Z_c3(end-1,:),'Color','b');
arrow(o,Z_c3(end,:),'Color','b');
xlim([-1 1])
ylim([-1 1])
zlim([-1 1])
title('Line_{31} of cycle 3')
set(gca, 'FontSize', 10); % Increase font size
set(gca, 'LineWidth', 1.5); % Make lines thicker
set(gca, 'FontName', 'Times New Roman'); % Set preferred font

subplot(2,2,4)
view(3)
plot3(Z_c4(1:end-2,1),Z_c4(1:end-2,2),Z_c4(1:end-2,3),'r*','MarkerSize',20)
arrow(o,Z_c4(end-1,:),'Color','b');
arrow(o,Z_c4(end,:),'Color','b');
xlim([-1 1])
ylim([-1 1])
zlim([-1 1])
title('Line_{41} of cycle 4')
set(gca, 'FontSize', 10); % Increase font size
set(gca, 'LineWidth', 1.5); % Make lines thicker
set(gca, 'FontName', 'Times New Roman'); % Set preferred font
```



Line$_{11}$ of cycle 1

Line$_{21}$ of cycle 2

Line$_{31}$ of cycle 3

Line$_{41}$ of cycle 4

```
%sgtitle('AIME components of Iris data');
```

```
% Correlation table
corr_line_PC = round(abs([w1_real;w2_real;w3_real;w4_real]),4);
rowNames = {'Line1', 'Line2', 'Line3', 'Line4'};
colNames = {'PC1', 'PC2', 'PC3', 'PC4'};
T_corr = array2table(corr_line_PC, 'RowNames', rowNames, 'VariableNames',
colNames);
disp(T_corr);
```

```
              PC1       PC2       PC3       PC4  
             ______    ______    ______    ______

    Line1    0.9996    0.0236    0.0096     0.002
    Line2    0.0251    0.9974    0.0234     0.063
    Line3     0.002    0.0223    0.9986    0.0527
    Line4     0.012    0.0353    0.0192    0.9991
```

```
% variance table
var_line_PC = round(abs([true_PC_var_accum;AIME_accum]),3);
rowNames = {'true PC', 'AIME components'};
colNames = {'cycle 1', 'cycle 2', 'cycle 3', 'cycle 4'};
T_var = array2table(var_line_PC, 'RowNames', rowNames, 'VariableNames',
colNames);
disp(T_var);
```

	cycle 1	cycle 2	cycle 3	cycle 4
true PC	0.922	0.976	0.995	1
AIME components	0.924	0.977	0.995	1