ECE 313 Final Project Report

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April 25, 2017

Task 0:

```
clear all;
clc;

load 1_a41178.mat;
patient1_data = floor(all_data);
patient1_labels = all_labels;
training1 = patient1_data(:,1:(2*length(patient1_data)/3));
testing1 = patient1_data(:,(2*length(patient1_data)/3):length(patient1_data));
label_training1 = patient1_labels(1:(2*length(patient1_labels)/3));
label_testing1 = patient1_labels((2*length(patient1_labels)/3):length(patient1_labels));

load 2_a42126.mat;
patient2_data = floor(all_data);
patient2_labels = all_labels;
training2 = patient2_data(:,1:floor(2*length(patient2_data)/3));
testing2 = patient2_data(:,floor(2*length(patient2_data)/3):length(patient2_data));
label_training2 = patient2_labels(1:floor(2*length(patient2_labels)/3));
label_testing2 = patient2_labels(floor(2*length(patient2_labels)/3):length(patient2_labels));

load 3_a40076.mat;
patient3_data = floor(all_data);
patient3_labels = all_labels;
training3 = patient3_data(:,1:(2*length(patient3_data)/3));
testing3 = patient3_data(:,(2*length(patient3_data)/3):length(patient3_data));
label_training3 = patient3_labels(1:(2*length(patient3_labels)/3));
label_testing3 = patient3_labels((2*length(patient3_labels)/3):length(patient3_labels));

load 4_a40050.mat;
patient4_data = floor(all_data);
patient4_labels = all_labels;
training4 = patient4_data(:,1:floor(2*length(patient4_data)/3));
```

```
testing4 = patient4_data(:,floor(2*length(patient4_data)/3):length(patient4_data));
label_training4 = patient4_labels(1:floor(2*length(patient4_labels)/3));
label_testing4 = patient4_labels(floor(2*length(patient4_labels)/3):length(patient4_labels));

load 5_a41287.mat;
patient5_data = floor(all_data);
patient5_labels = all_labels;
training5 = patient5_data(:,1:(2*length(patient5_data)/3));
testing5 = patient5_data(:,(2*length(patient5_data)/3):length(patient5_data));
label_training5 = patient5_labels(1:(2*length(patient5_labels)/3));
label_testing5 = patient5_labels((2*length(patient5_labels)/3):length(patient5_labels));

load 6_a41846.mat;
patient6_data = floor(all_data);
patient6_labels = all_labels;
training6 = patient6_data(:,1:floor(2*length(patient6_data)/3));
testing6 = patient6_data(:,floor(2*length(patient6_data)/3):length(patient6_data));
label_training6 = patient6_labels(1:floor(2*length(patient6_labels)/3));
label_testing6 = patient6_labels(floor(2*length(patient6_labels)/3):length(patient6_labels));

load 7_a41846.mat;
patient7_data = floor(all_data);
patient7_labels = all_labels;
training7 = patient7_data(:,1:floor(2*length(patient7_data)/3));
testing7 = patient7_data(:,floor(2*length(patient7_data)/3):length(patient7_data));
label_training7 = patient7_labels(1:floor(2*length(patient7_labels)/3));
label_testing7 = patient7_labels(floor(2*length(patient7_labels)/3):length(patient7_labels));

load 8_a42008.mat;
patient8_data = floor(all_data);
patient8_labels = all_labels;
training8 = patient8_data(:,1:(2*length(patient8_data)/3));
testing8 = patient8_data(:,(2*length(patient8_data)/3):length(patient8_data));
label_training8 = patient8_labels(1:(2*length(patient8_labels)/3));
label_testing8 = patient8_labels((2*length(patient8_labels)/3):length(patient8_labels));

load 9_a41846.mat;
patient9_data = floor(all_data);
patient9_labels = all_labels;
training9 = patient9_data(:,1:floor(2*length(patient9_data)/3))
```

```
;
testing9 = patient9_data(:,floor(2*length(patient9_data)/3):length(patient9_data));
label_training9 = patient9_labels(1:floor(2*length(patient9_labels)/3));
label_testing9 = patient9_labels(floor(2*length(patient9_labels)/3):length(patient9_labels));
```

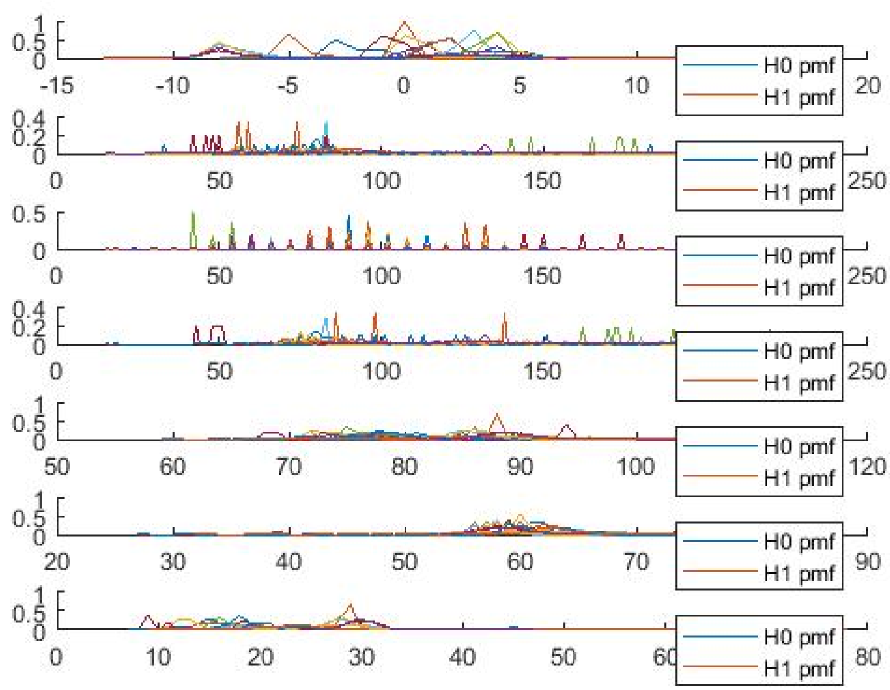
For task 0 we took the raw patient and gold data and partitioned it into testing and training segments.

Task 1.1:

```
HT_table_array_pat_1 = Get_HT_table(1, training1, label_training1);
HT_table_array_pat_2 = Get_HT_table(2, training2, label_training2);
HT_table_array_pat_3 = Get_HT_table(3, training3, label_training3);
HT_table_array_pat_4 = Get_HT_table(4, training4, label_training4);
HT_table_array_pat_5 = Get_HT_table(5, training5, label_training5);
HT_table_array_pat_6 = Get_HT_table(6, training6, label_training6);
HT_table_array_pat_7 = Get_HT_table(7, training7, label_training7);
HT_table_array_pat_8 = Get_HT_table(8, training8, label_training8);
HT_table_array_pat_9 = Get_HT_table(9, training9, label_training9);

HT_table_array = cat(1, HT_table_array_pat_1, HT_table_array_pat_2,
     HT_table_array_pat_3, HT_table_array_pat_4,
    HT_table_array_pat_5, HT_table_array_pat_6,
    HT_table_array_pat_7, HT_table_array_pat_8,
    HT_table_array_pat_9);
```

```
function HT_table_array_pat = Get_HT_table(patient_index, patient_data, patient_labels)

% Prior probablities, alarms/total
P_H1 = sum(patient_labels)/length(patient_labels);
P_H0 = 1 - P_H1;

HT_table_array_pat = cell(1, 7);

% name = strcat('Patient_', int2str(patient_index), '_Features');
% figure('name', name, 'unit', 'normalized', 'outerposition', [.1 .1 .8 .8]);

for i = 1:7
  [feature_mat, x_mat] = Get_Feat_Mat(patient_data(i:i, :), patient_labels);

  ML_vector = zeros(1, length(feature_mat(1:1, :)));
  MAP_vector = zeros(1, length(feature_mat(1:1, :)));

  for k = 1:length(feature_mat(1:1, :))
    P_H1_i = feature_mat(1, k);
    P_H0_i = feature_mat(2, k);
    if (P_H1_i >= P_H0_i)
      % if H1_pmf >= H0_pmf
```

```
        ML_vector(k) = 1;
      end
      if (P_H1*P_H1_i >= P_H0*P_H0_i)
        % if H1_pmf*P(H1) >= H0_pmf*P(H0)
        MAP_vector(k) = 1;
      end
    end

    HT_table = cat(1, x_mat, feature_mat(1:1, :), feature_mat(2:2, :)
      , ML_vector, MAP_vector);
    HT_table = rot90(HT_table, -1);
    HT_table = fliplr(HT_table);
    % Have to flip the table so that it matches with the given format
    HT_table_array_pat{1, i} = num2cell(HT_table);
    subplot(7, 1, i);
    hold on;
    plot(x_mat, feature_mat(1:1, :));
    plot(x_mat, feature_mat(2:2, :));
    legend('H0 pmf', 'H1 pmf');
    hold off;
end
```



Above is our data after we created the probability matricies. **Task 1.2:**

```
Error_table_arrar_pat_1 = Get_Error_table(HT_table_array_pat_1, testing1, label_testing1);
Error_table_arrar_pat_2 = Get_Error_table(HT_table_array_pat_2, testing2, label_testing2);
Error_table_arrar_pat_3 = Get_Error_table(HT_table_array_pat_3, testing3, label_testing3);
Error_table_arrar_pat_4 = Get_Error_table(HT_table_array_pat_4, testing4, label_testing4);
Error_table_arrar_pat_5 = Get_Error_table(HT_table_array_pat_5, testing5, label_testing5);
Error_table_arrar_pat_6 = Get_Error_table(HT_table_array_pat_6, testing6, label_testing6);
Error_table_arrar_pat_7 = Get_Error_table(HT_table_array_pat_7, testing7, label_testing7);
Error_table_arrar_pat_8 = Get_Error_table(HT_table_array_pat_8, testing8, label_testing8);
Error_table_arrar_pat_9 = Get_Error_table(HT_table_array_pat_9, testing9, label_testing9);

Error_table_arrar = cat(1, Error_table_arrar_pat_1,
  Error_table_arrar_pat_2, Error_table_arrar_pat_3,
  Error_table_arrar_pat_4, Error_table_arrar_pat_5,
  Error_table_arrar_pat_6, Error_table_arrar_pat_7,
  Error_table_arrar_pat_8, Error_table_arrar_pat_9);

```

```
function Error_table_pat = Get_Error_table(HT_table_array_pat, patient_data, patient_labels)

Error_table_pat = cell(1, 7);

for i = 1:7
    % Get feature from the parameter
  feature_table = HT_table_array_pat{1, i};
    feature_data = patient_data(i:i, :);
    % Offset the data
  feature_data_off = feature_data - min(feature_data) + 1;

    % Get the vectors and organize
  ML_vector = cell2mat(feature_table(:, 4:4));
  MAP_vector = cell2mat(feature_table(:, 5:5));
  ML_vector = rot90(ML_vector);
  MAP_vector = rot90(MAP_vector);
    ML_vector_off = zeros(1, max(feature_data_off));
  MAP_vector_off = zeros(1, max(feature_data_off));
  for k = 1:length(ML_vector)
    ML_vector_off(k) = ML_vector(k);
    MAP_vector_off(k) = MAP_vector(k);
    end

    % Alarms generated by vectors
    ML_vector_alarm = zeros(1, length(patient_labels));
  MAP_vector_alarm = zeros(1, length(patient_labels));
  for k = 1:length(feature_data_off)
```

```
      j = feature_data_off(k);
      if (ML_vector_off(j) == 1)
        ML_vector_alarm(k) = 1;
      end
      if (MAP_vector_off(j) == 1)
        MAP_vector_alarm(k) = 1;
      end
      end

      % count the errors
    FA_count_ML = 0;
    MD_count_ML = 0;
    FA_count_MAP = 0;
    MD_count_MAP = 0;
    for k = 1:length(patient_data)
      if (patient_labels(k) == 1)
        if (ML_vector_alarm(k) == 0)
          MD_count_ML = MD_count_ML + 1;
        end
        if (MAP_vector_alarm(k) == 0)
          MD_count_MAP = MD_count_MAP + 1;
        end
      else
        if (ML_vector_alarm(k) == 1)
          FA_count_ML = FA_count_ML + 1;
        end
        if (MAP_vector_alarm(k) == 1)
          FA_count_MAP = FA_count_MAP + 1;
        end
      end
      end

      % Contruct the error table
      Error_table = zeros(2, 3);
    number_alarm = sum(patient_labels);
    total_alarm = length(patient_labels);
    Error_table(1, 1) = FA_count_ML/(total_alarm - number_alarm);
    Error_table(1, 2) = MD_count_ML/number_alarm;
    Error_table(1, 3) = (FA_count_ML + MD_count_ML)/total_alarm;
    Error_table(2, 1) = FA_count_MAP/(total_alarm - number_alarm)
  ;
    Error_table(2, 2) = MD_count_MAP/number_alarm;
    Error_table(2, 3) = (FA_count_MAP + MD_count_MAP)/total_alarm
  ;
    Error_table_pat{1, i} = num2cell(Error_table);
  end
```

Above you can see we created the Ml and map rule errors for the matrix.

Task 2.1:

```
patient_data_array = cell(1, 9);
patient_data_array{1, 1} = num2cell(patient1_data);
patient_data_array{1, 2} = num2cell(patient2_data);
patient_data_array{1, 3} = num2cell(patient3_data);
patient_data_array{1, 4} = num2cell(patient4_data);
```

```
patient_data_array{1, 5} = num2cell(patient5_data);
patient_data_array{1, 6} = num2cell(patient6_data);
patient_data_array{1, 7} = num2cell(patient7_data);
patient_data_array{1, 8} = num2cell(patient8_data);
patient_data_array{1, 9} = num2cell(patient9_data);

corrcoef_array = cell(9, 9, 7);
for i = 1:7
    for m = 1:9
        for n = 1:9
            patient_data_m = cell2mat(patient_data_array{1, m});
            patient_data_n = cell2mat(patient_data_array{1, n});
            feature_table_m = patient_data_m(i:i, :);
            feature_table_n = patient_data_n(i:i, :);
            % Can't corrcoef if dimensions are different
            % Expand the array by adding a zero to the right position
            array_size = max(length(feature_table_m), length(feature_table_n));
            feature_table_m(array_size) = 0;
            feature_table_n(array_size) = 0;
            corr_coef = corrcoef(feature_table_m, feature_table_n);
            corrcoef_array{m, n, i} = corr_coef(1, 2);
        end
    end
end
```

Essentially for 2.1 we iterated through every possibility of patient and feature combination to see that the correlation between patient 6 and patient 9 is always 1 so they have the same data.

Task 2.2:

```
feat1,feat2] = find_lowest_eror(Error_table_arrar); % find possible features using addition of errors
[feat3,feat4] = find_lowest_corr(training1,training2,training3,training4,training5,training6,training7,training8,training9);
% after the 2 data analysis runs, we have feat1 = 5, feat2 = 7, feat3 = 2,
% feat4 = 7. the pair 5&7 has a error sum of 5: 2.2, 7:2.4, and a
% correlation magnitude of .8346 which is terrrible. while the error sum of
% 2: 3.6 is not terrible and the correlation of 2 and 7 is at a minimum of
% the set at .0192
```

```
function [ feature1,feature2 ] = find_lowest_eror( error_arr )

    local_error = 0;
    global_error = 1000000;
```

```
        global_error2 = 1000000;
        local_feat1 = 0;
        local_feat2 = 0;
        for i=1:7
            for j=1:9
                cel = error_arr{j,i};
                error_feature = cel{1,3} + cel{2,3}; % sum up error for that feature in that patient
                local_error = local_error + error_feature; % add to local sum and move to next patient
            end
            if(local_error <= global_error)
                global_error = local_error;
                local_feat2 = local_feat1;
                local_feat1 = i;
            else
                if(local_error <= global_error2)
                    global_error2 = local_error;
                    local_feat2 = i;
                end

            end
            local_error = 0;
        end


        feature1 = local_feat1;
        feature2 = local_feat2;

    end


```

```
function [ feature1,feature2 ] = find_lowest_corr( pat1,pat2,pat3,pat4,pat5,pat6,pat7,pat8,pat9 )
    f1 =  cat(2,pat1(1,:),pat2(1,:),pat3(1,:),pat4(1,:),pat5(1,:),pat6(1,:),pat7(1,:),pat8(1,:),pat9(1,:));
    f2 =  cat(2,pat1(2,:),pat2(2,:),pat3(2,:),pat4(2,:),pat5(2,:),pat6(2,:),pat7(2,:),pat8(2,:),pat9(2,:));
    f3 =  cat(2,pat1(3,:),pat2(3,:),pat3(3,:),pat4(3,:),pat5(3,:),pat6(3,:),pat7(3,:),pat8(3,:),pat9(3,:));
    f4 =  cat(2,pat1(4,:),pat2(4,:),pat3(4,:),pat4(4,:),pat5(4,:),pat6(4,:),pat7(4,:),pat8(4,:),pat9(4,:));
    f5 =  cat(2,pat1(5,:),pat2(5,:),pat3(5,:),pat4(5,:),pat5(5,:),pat6(5,:),pat7(5,:),pat8(5,:),pat9(5,:));
    f6 =  cat(2,pat1(6,:),pat2(6,:),pat3(6,:),pat4(6,:),pat5(6,:),pat6(6,:),pat7(6,:),pat8(6,:),pat9(6,:));
    f7 =  cat(2,pat1(7,:),pat2(7,:),pat3(7,:),pat4(7,:),pat5(7,:),pat6(7,:),pat7(7,:),pat8(7,:),pat9(7,:));
    local_min = 0;
    global_min = 10;
    features = [f1;f2;f3;f4;f5;f6;f7]; % make 2d array of feature data for all patients
    for i =1:6
```

```
        for j = (i+1):7
            corr = corrcoef(features(i,:),features(j,:)); % should be a 2x2 with flipped entries in each col so just sum column
            local_min = abs(corr(1,2)); % looking for smallest mag of correlation because this fits description better

            if(global_min >= local_min)
                global_min = local_min;
                feature1 = i;
                feature2 = j;
            end
            local_min = 0;
        end
    end
    % concatenate each feature data for each patient;


end
```

After examining the output of the two functions and interpreting the data, we were left with the pairs of feature 5 and 7 or 2 and 7. If we analyze the error for each one and the correlation of them, the 2 and 7 pair is much better suited. so we have chosen those two features. However, we can use 5 and 7 for future hypothesis testing because of their low error.