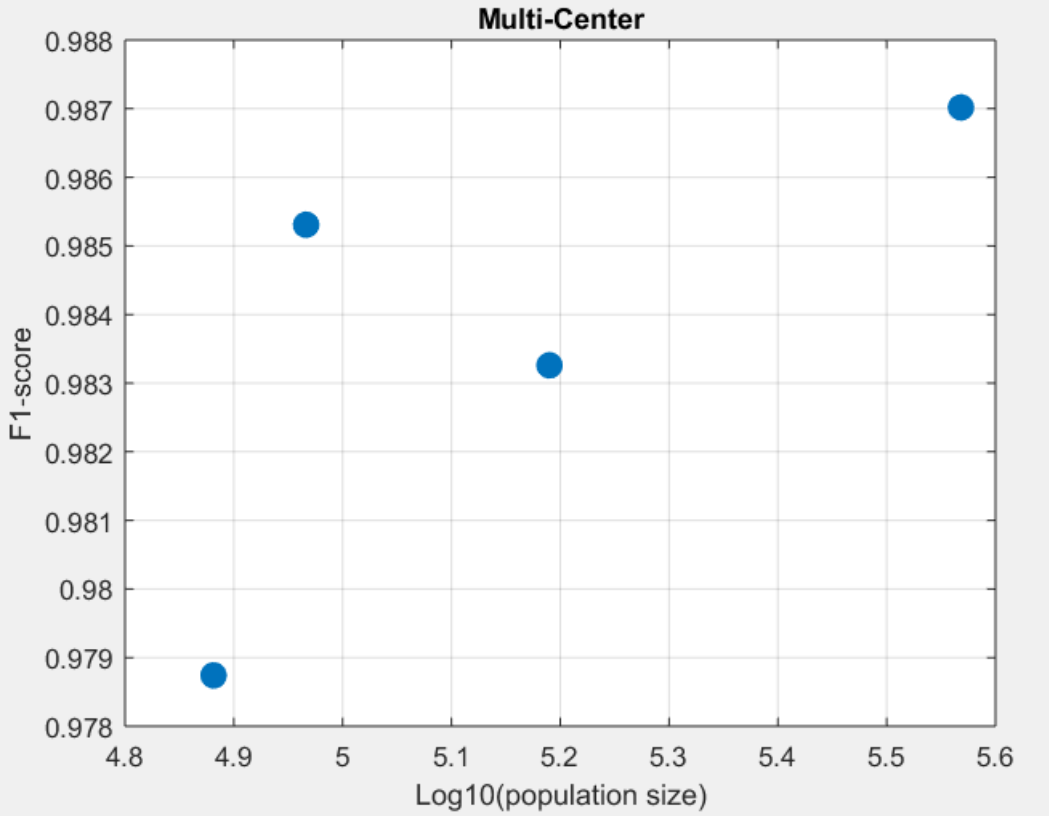
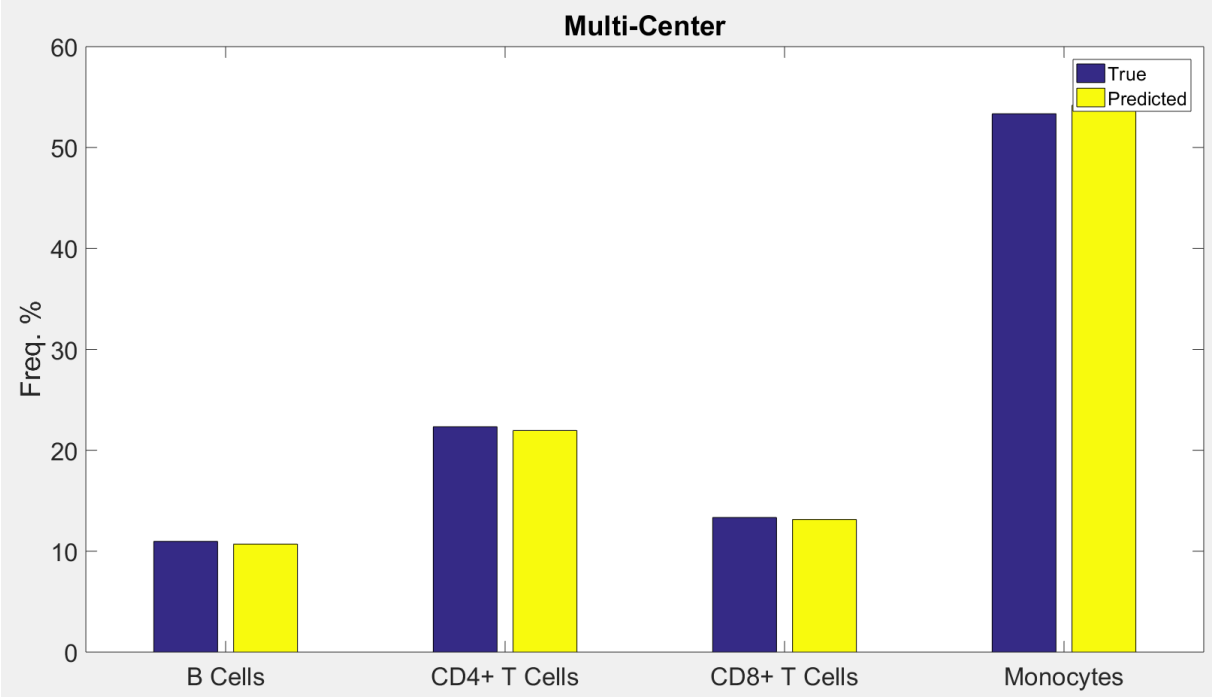
Multi-Center Dataset Classification

```
%% Read the Data and Preprocess

>> VarNames = {'CCR6','CD20','CD45','CD14','CD16','CD8', ...
   'CD3','CD4'};
>> SamplesData=struct('Data',[],'Labels',{});

>> H=dir(fullfile('Samples\', '*.csv'));
>> SamplesFiles = cellstr(char(H(1:end).name));

>> H=dir(fullfile('Labels\', '*.csv'));
>> LabelsFiles = cellstr(char(H(1:end).name));
>> clear H

>> for i=1:length(SamplesFiles)
>>     SamplesData(i).Data = csvread(['Samples\' SamplesFiles{i}]);
>>     SamplesData(i).Labels = csvread(['Labels\' LabelsFiles{i}]);
>> end
>> clear i SamplesFiles LabelsFiles

>> Labels = [];
>> for i=1:length(SamplesData)
>>     % Apply arcsinh5 transformation
>>     SamplesData(i).Data = asinh((SamplesData(i).Data-1)/5);
>>     Labels = [Labels; SamplesData(i).Labels];
>> end
>> clear i

%% run LDA Classifier with 4-fold cross-validation on samples

>> CVO = cvpartition(1:1:16,'k',4);
>> Accuracy = zeros(length(SamplesData),1);
>> training_time = zeros(CVO.NumTestSets,1);
>> testing_time = zeros(length(SamplesData),1);
>> CellTypes = unique(Labels);
>> ConfusionMat = zeros(length(CellTypes));
>> WeightedFmeasure = zeros(length(SamplesData),1);
>> for i = 1:CVO.NumTestSets
>>     trIdx = find(CVO.training(i));
>>     teIdx = find(CVO.test(i));

>>     DataTrain=[];
>>     LabelsTrain=[];
>>     for j=1:length(trIdx)
>>         DataTrain = [DataTrain; SamplesData(trIdx(j)). ...
           Data(SamplesData(trIdx(j)).Labels~=0,:)];
>>         LabelsTrain = [LabelsTrain; SamplesData(trIdx(j)). ...
           Labels(SamplesData(trIdx(j)).Labels~=0)];
>>     end
>>     clear j
```

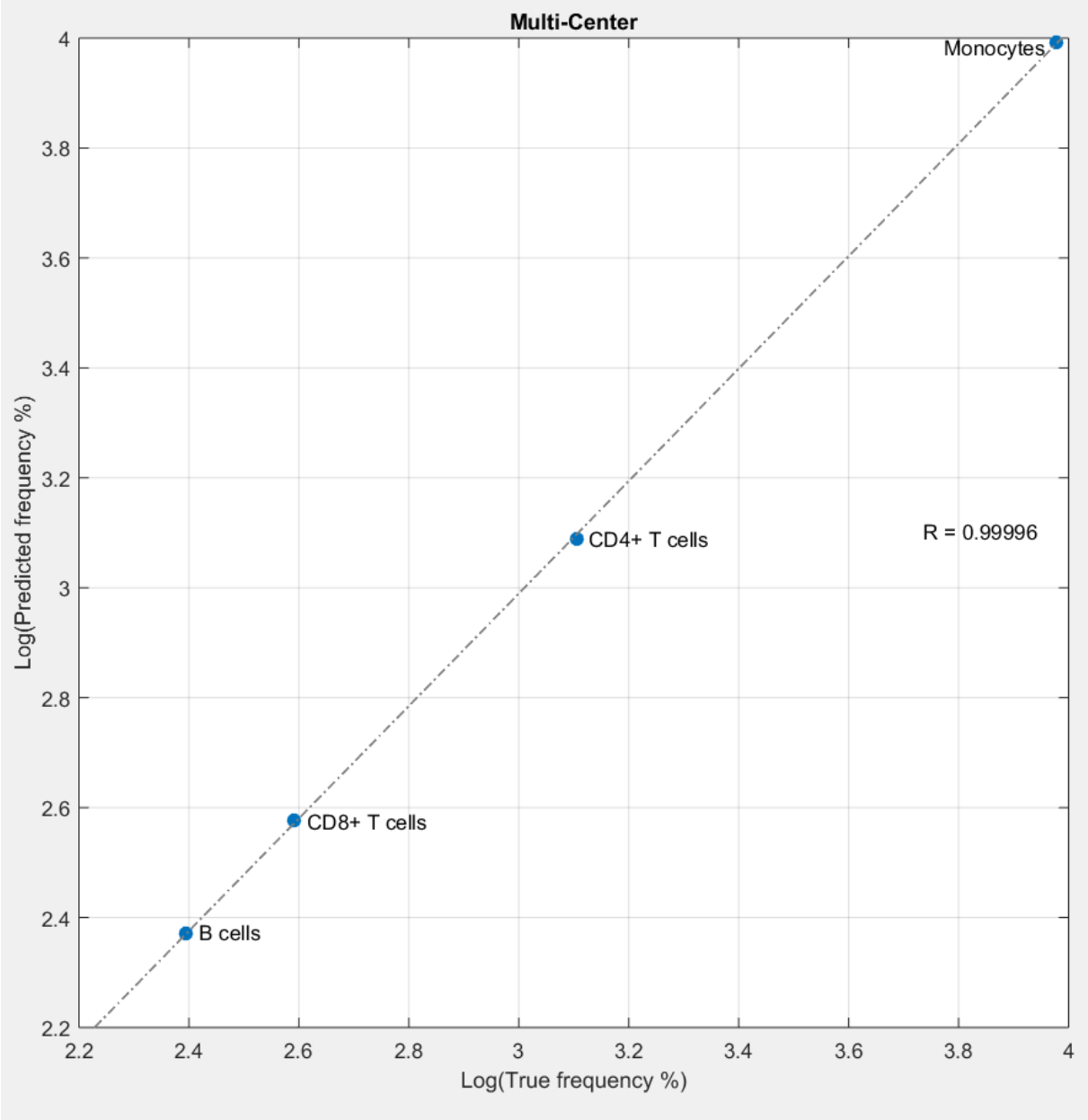
```
>>     tic
>>     classificationLDA = fitcdiscr(...
        DataTrain, ...
        LabelsTrain);
>>     training_time(i)=toc;          %in seconds

>>     for j=1:length(teIdx)
>>         tic
>>         [Predictor,scores] = predict(classificationLDA, ...
           SamplesData(teIdx(j)).Data);
>>         Current_Scores = max(scores,[],2);
>>         Predictor(Current_Scores < 0.4)=0;
>>         testing_time(teIdx(j))=toc;           %in seconds
>>         Accuracy(teIdx(j)) = nnz(Predictor(SamplesData ...
           (teIdx(j)).Labels~=0)==SamplesData(teIdx(j)). ...
           Labels(SamplesData(teIdx(j)).Labels~=0))...
           /size(SamplesData(teIdx(j)).Labels(SamplesData ...
           (teIdx(j)).Labels~=0),1);
>>         ConfusionMat = ConfusionMat + confusionmat(SamplesData...
           (teIdx(j)).Labels,Predictor,'order',CellTypes);
>>     end
>>     clear j
>> end
>> Total_time = sum(training_time)+sum(testing_time);
>> training_time = mean(training_time);
>> testing_time = mean(testing_time);
>> cvAcc = mean(Accuracy)*100;
>> cvSTD = std(Accuracy)*100;
>> disp(['LDA Accuracy = ' num2str(cvAcc) ' ' char(177) ' '...
   num2str(cvSTD) ' %'])

LDA Accuracy = 98.4426 ± 1.6561 %

>> clear i Predictor classificationLDA trIdx teIdx CVO Accuracy
   DataTrain LabelsTrain


%% Performance evaluation
>> col1 = ConfusionMat(2:end,1);
>> ConfusionMat = ConfusionMat(2:end,2:end);
% F1 measure
>> Precision = diag(ConfusionMat)./sum(ConfusionMat,1)';
>> Recall = diag(ConfusionMat)./(sum(ConfusionMat,2)+col1);
>> Fmeasure = 2 * (Precision.*Recall)./(Precision+Recall);
>> MedianFmeasure = median(Fmeasure);
>> Subset_size = sum(ConfusionMat,2)+col1;
>> WeightedFmeasure = (Subset_size./sum(Subset_size))'*Fmeasure;

>> disp(['Weighted F1-score = ' num2str(WeightedFmeasure)])

Weighted F1-score = 0.98504

>> figure,scatter(log10(Subset_size),Fmeasure,100,'filled')
>> title('Multi-Center')
>> xlabel('Log10(population size)'),ylabel('F1-score')
>> box on, grid on
```




```
%% Population Frequency

>> True_Freq = (sum(ConfusionMat,2)+col1)./ ...
   (sum(sum(ConfusionMat))+sum(col1));
>> Predicted_Freq = sum(ConfusionMat,1)'./ ...
(sum(sum(ConfusionMat))+sum(col1));
>> Max_Freq_diff = max(abs(True_Freq-Predicted_Freq))*100;

delta_f = 0.83083

>> figure,bar([True_Freq*100 Predicted_Freq*100])
>> xticklabels({'B Cells','CD4+ T Cells', ...
   'CD8+ T Cells','Monocytes'})
>> set(gca,'FontSize',20)
>> legend({'True','Predicted'},'FontSize',15)
>> legend show
>> ylabel('Freq. %'),title('Multi-Center')
```




```
%% Population Frequency scatter plot

>> CellTypes = {'B cells','CD4+ T cells','CD8+ T
cells','Monocytes'};
>> X=log(True_Freq*100);
>> Y=log(Predicted_Freq*100);
>> figure,scatter(X,Y,50,'filled')
>> box on, grid on
>> xlabel('Log(True frequency %)')
>> ylabel('Log(Predicted frequency %)')
>> title('Multi-Center')
>> for k=1:length(CellTypes)
>>     text(X(k),Y(k),CellTypes{k})
>> end
>> lsline
>> text(3,3,['R = ' num2str(corr(X,Y))])
```


Multi-Center
Monocytes
CD4+ T cells
CD8+ T cells
B cells
R = 0.99996
Log(Predicted frequency %)
Log(True frequency %)
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4