Classification of Regions with Transition Graphs

Eduarda Chagas

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In this script, we will evaluate the performance of the WATG technique for region classification in PolSAR textures.

Importing the packages

```
# Clear workspace:
rm(list = ls())

# Load some packages:
if(!require(caret)) install.packages("caret")
```

```
## Loading required package: caret
```

```
## Loading required package: lattice
```

```
## Loading required package: ggplot2
```

```
if(!require(MLmetrics)) install.packages("MLmetrics")
```

```
## Loading required package: MLmetrics
```

```
##
## Attaching package: 'MLmetrics'
```

```
## The following objects are masked from 'package:caret':
##
##     MAE, RMSE
```

```
## The following object is masked from 'package:base':
##
##     Recall
```

```
setwd("/home/eduarda/Desktop/Research/Repositories/PolSARfromITQualitative/Code/Classification")
```

Importing the dataset

For this analysis, three SAR images with different regions were used, they are:

- Sierra del Lacandon National Park, Guatemala (purchased April 10, 2015), available at [https://uavsar.jpl.nasa.gov/cgi-bin/product.pl?jobName=Lacand_30202_15043_ 006_150410_L090_CX_01 # data] (https://uavsar.jpl.nasa.gov/cgi-bin/product.pl?jobName=Lacand_30202_15043_006_150410_L090_CX_01 # data);
- Oceanic regions of Cape Canaveral (acquired on September 22, 2016);
- Urban area of the city of Munich, Germany (acquired on June 5, 2015).

A total of 160 samples were considered during the investigation, with 40 forest regions in Guatemala, 80 ocean regions in Cape Canaveral and 40 urban regions in the city of Munich.

```
n.total = 160
regions = c(rep("Forest",40), rep("Sea",80), rep("Urban", 40))

Entropy.Complexity = data.frame("Entropy" = numeric(n.total),
                                "Complexity" = numeric(n.total),
                                "Region" = character(n.total),
                                stringsAsFactors=FALSE)

Entropy.Complexity.csv = read.csv(file="../../Data/EntropyComplexityTGD3T1.csv",
                                  header=TRUE, sep=",")
Entropy.Complexity$Entropy = Entropy.Complexity.csv[,1]
Entropy.Complexity$Complexity = Entropy.Complexity.csv[,2]
Entropy.Complexity$Region = regions

split = 0.85
trainIndex = createDataPartition(Entropy.Complexity$Region, p = split, list = FALSE)

x = data.frame(Entropy.Complexity$Entropy[trainIndex], Entropy.Complexity$Complexity[trainIndex])
y = factor(Entropy.Complexity$Region[trainIndex])

x_validation = data.frame("Entropy" = Entropy.Complexity$Entropy[-trainIndex], "Complexity" = Entropy.C
y_validation = factor(Entropy.Complexity$Region[-trainIndex])

Entropy.Complexity = data.frame("Entropy" = Entropy.Complexity$Entropy[trainIndex],
                                "Complexity" = Entropy.Complexity$Complexity[trainIndex],
                                "Region" = Entropy.Complexity$Region[trainIndex],
                                stringsAsFactors=FALSE)
```

KNN Classifier

Creating KNN model and predicting

```
set.seed(123)
ctrl = trainControl(method="repeatedcv", number = 10, repeats = 10)
knnFit = train(Region~., data = Entropy.Complexity, method = "knn",
               trControl = ctrl,
               preProcess = c("center","scale"),
               tuneLength = 20)

pred = predict(knnFit, newdata = x_validation)

xtab = table(pred, y_validation)
confusionMatrix(xtab)
```

```
## Confusion Matrix and Statistics
##
##          y_validation
## pred      Forest Sea Urban
##   Forest       2   1     0
##   Sea          3  11     0
##   Urban        1   0     6
##
```

```
## Overall Statistics
##
##                Accuracy : 0.7917
##                  95% CI : (0.5785, 0.9287)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.003305
##
##                   Kappa : 0.6552
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Forest Class: Sea Class: Urban
## Sensitivity                0.33333     0.9167       1.0000
## Specificity                0.94444     0.7500       0.9444
## Pos Pred Value             0.66667     0.7857       0.8571
## Neg Pred Value             0.80952     0.9000       1.0000
## Prevalence                 0.25000     0.5000       0.2500
## Detection Rate             0.08333     0.4583       0.2500
## Detection Prevalence       0.12500     0.5833       0.2917
## Balanced Accuracy          0.63889     0.8333       0.9722
```

```
knnFit
```

```
## k-Nearest Neighbors
##
## 136 samples
##   2 predictor
##   3 classes: 'Forest', 'Sea', 'Urban'
##
## Pre-processing: centered (2), scaled (2)
## Resampling: Cross-Validated (10 fold, repeated 10 times)
## Summary of sample sizes: 122, 122, 122, 122, 123, 123, ...
## Resampling results across tuning parameters:
##
##   k   Accuracy   Kappa
##    5  0.8239725  0.7122315
##    7  0.7965769  0.6660231
##    9  0.7787729  0.6342520
##   11  0.7720092  0.6215437
##   13  0.7574634  0.5943533
##   15  0.7519634  0.5841278
##   17  0.7498004  0.5768107
##   19  0.7497271  0.5741239
##   21  0.7378278  0.5556638
##   23  0.7302381  0.5443173
##   25  0.7235714  0.5338315
##   27  0.7171758  0.5225734
##   29  0.7102418  0.5098416
##   31  0.7006209  0.4915356
##   33  0.6938535  0.4769637
##   35  0.6817766  0.4565563
##   37  0.6721300  0.4380707
##   39  0.6668846  0.4284286
```

```
##   41  0.6616795  0.4168060
##   43  0.6551667  0.4042251
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was k = 5.
```

```
cat("Accuracy: ", Accuracy(pred, y_validation), " Recall: ", Recall(pred, y_validation), " Precision: "
```

```
## Accuracy:  0.7916667  Recall:  0.6666667  Precision:  0.3333333  F1-Score:  0.4444444
```

SVM Classifier

Creating svm model using non-linear kernel

```
svmFit <- train(Region ~., data = Entropy.Complexity, method = "svmRadial",
                trControl=ctrl,
                preProcess = c("center", "scale"),
                tuneLength = 20)
pred = predict(svmFit, newdata = x_validation)

xtab = table(pred, y_validation)
confusionMatrix(xtab)
```

```
## Confusion Matrix and Statistics
##
##          y_validation
## pred      Forest Sea Urban
##   Forest       2   1     0
##   Sea          3  11     0
##   Urban        1   0     6
##
## Overall Statistics
##
##                Accuracy : 0.7917
##                  95% CI : (0.5785, 0.9287)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 0.003305
##
##                   Kappa : 0.6552
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Forest Class: Sea Class: Urban
## Sensitivity                0.33333     0.9167       1.0000
## Specificity                0.94444     0.7500       0.9444
## Pos Pred Value             0.66667     0.7857       0.8571
## Neg Pred Value             0.80952     0.9000       1.0000
## Prevalence                 0.25000     0.5000       0.2500
## Detection Rate             0.08333     0.4583       0.2500
## Detection Prevalence       0.12500     0.5833       0.2917
## Balanced Accuracy          0.63889     0.8333       0.9722
```

```
cat("Accuracy: ", Accuracy(pred, y_validation), " Recall: ", Recall(pred, y_validation), " Precision: "
```

```
## Accuracy:  0.7916667  Recall:  0.6666667  Precision:  0.3333333  F1-Score:  0.4444444
```

Random Forest Classifier

Creating Random Forest model and predicting

```
rfFit <- train(Region~., data = Entropy.Complexity, method = "rf",
               trControl = ctrl,
               preProcess = c("center","scale"),
               tuneLength = 20)
```

```
## note: only 1 unique complexity parameters in default grid. Truncating the grid to 1 .
```

```
pred = predict(rfFit, newdata = x_validation)
```

```
cat("Accuracy: ", Accuracy(pred, y_validation), " Recall: ", Recall(pred, y_validation), " Precision: "
```

```
## Accuracy:  0.8333333  Recall:  0.75  Precision:  0.5  F1-Score:  0.6
```