Classification of Regions with Transition Graphs

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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/EntropyComplexityWATG.csv",
                                  header=TRUE, sep=",")
Entropy.Complexity$Entropy = Entropy.Complexity.csv[1:n.total, 1]
Entropy.Complexity$Complexity = Entropy.Complexity.csv[1:n.total, 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)
cm = confusionMatrix(xtab)
cm
```

```
## Confusion Matrix and Statistics
##
##          y_validation
## pred      Forest Sea Urban
##   Forest       6   0     0
##   Sea          0  12     0
```

```
##   Urban       0   0     6
##
## Overall Statistics
##
##                Accuracy : 1
##                  95% CI : (0.8575, 1)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 5.96e-08
##
##                   Kappa : 1
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Forest Class: Sea Class: Urban
## Sensitivity                   1.00        1.0         1.00
## Specificity                   1.00        1.0         1.00
## Pos Pred Value                1.00        1.0         1.00
## Neg Pred Value                1.00        1.0         1.00
## Prevalence                    0.25        0.5         0.25
## Detection Rate                0.25        0.5         0.25
## Detection Prevalence          0.25        0.5         0.25
## Balanced Accuracy             1.00        1.0         1.00
```

```
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  0.9926209  0.9884813
##    7  0.9926209  0.9884813
##    9  0.9926209  0.9884813
##   11  0.9926209  0.9884813
##   13  0.9911374  0.9859129
##   15  0.9918132  0.9863123
##   17  0.9963187  0.9938175
##   19  0.9910989  0.9851923
##   21  0.9925275  0.9874234
##   23  0.9955495  0.9924910
##   25  0.9932967  0.9887399
##   27  0.9925275  0.9874234
##   29  0.9918132  0.9862369
##   31  0.9940110  0.9899264
##   33  0.9947802  0.9912529
##   35  0.9947802  0.9912529
```

```
##   37  0.9925275  0.9874234
##   39  0.9941136  0.9901891
##   41  0.9883846  0.9806825
##   43  0.9876703  0.9794961
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was k = 17.
```

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

```
## Accuracy:  1  Recall:  1  Precision:  1  F1-Score:  1
```

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       6   0     0
##   Sea          0  12     0
##   Urban        0   0     6
##
## Overall Statistics
##
##                Accuracy : 1
##                  95% CI : (0.8575, 1)
##     No Information Rate : 0.5
##     P-Value [Acc > NIR] : 5.96e-08
##
##                   Kappa : 1
##
##  Mcnemar's Test P-Value : NA
##
## Statistics by Class:
##
##                      Class: Forest Class: Sea Class: Urban
## Sensitivity                   1.00        1.0         1.00
## Specificity                   1.00        1.0         1.00
## Pos Pred Value                1.00        1.0         1.00
## Neg Pred Value                1.00        1.0         1.00
## Prevalence                    0.25        0.5         0.25
## Detection Rate                0.25        0.5         0.25
## Detection Prevalence          0.25        0.5         0.25
```

```
## Balanced Accuracy             1.00        1.0         1.00
```

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

```
## Accuracy:  1  Recall:  1  Precision:  1  F1-Score:  1
```

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:  1  Recall:  1  Precision:  1  F1-Score:  1
```