Project

Someone

2025-04-15

```r
###Extracting features using grid partitioning


##Loading necessary libraries

library(jpeg)
```

```
## Warning: package 'jpeg' was built under R version 4.4.3
```

```r
##Defining Grid Feature Extraction Function

get_grid_features <- function(img,grid_size=10) {
  #Get image dimensions
  h <- dim(img)[1]
  w <- dim(img)[2]
  c <- dim(img)[3]

  #Size of each grid cell
  h_step <- floor(h / grid_size)
  w_step <- floor(w / grid_size)

  features <- c()
  for (i in 0:(grid_size - 1)){
    for (j in 0:(grid_size - 1)){
      for (k in 1:c) {
        patch <- img[(i * h_step + 1):min((i + 1) * h_step,h),
                     (j * w_step + 1):min((j + 1) * w_step, w), k]
        features <- c(features, median(patch))
      }
    }
  }
  return(features)
}
```

```r
##Apply to all images
photometadata <- read.csv("D:\\MATH 3333\\Winter 25\\Final Project\\photoMetaData.csv")
n <- nrow(photometadata)
grid_size <- 10
X_grid <- matrix (NA, nrow = n, ncol = grid_size * grid_size * 3)

for (j in 1:n) {
  img <- readJPEG(paste0("D:\\MATH 3333\\Winter 25\\Final Project\\columbiaImages\\columbiaImages\\", pl
  X_grid[j,] <- get_grid_features(img, grid_size)
  print(sprintf("%03d / %03d", j, n))
}
```

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```

```
##Using Random Forest

#Label and Split
```

```r
y <- as.numeric(photometadata$category == "outdoor-day")
set.seed(42)
trainFlag <- runif(length(y)) > 0.5

#Train a Random Forest
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 4.4.3
```

```
## randomForest 4.7-1.2
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```r
rf_model <- randomForest(x = X_grid[trainFlag, ],
                         y = as.factor(y[trainFlag]),
                         ntree = 200)

rf_model
```

```
##
## Call:
##  randomForest(x = X_grid[trainFlag, ], y = as.factor(y[trainFlag]),      ntree = 200)
##                Type of random forest: classification
##                      Number of trees: 200
## No. of variables tried at each split: 17
##
##         OOB estimate of  error rate: 22.31%
## Confusion matrix:
##     0  1 class.error
## 0 220 26   0.1056911
## 1  59 76   0.4370370
```

```r
##Predict and Evaluate

rf_pred_probs <- predict(rf_model, X_grid[!trainFlag, ], type = "prob")[,2]
rf_pred_class <- as.numeric(rf_pred_probs > 0.5)
y_test <- y[!trainFlag]

#Accuracy
rf_acc <- mean(rf_pred_class == y_test)

#Misclassification Error
rf_misc <- 1 - rf_acc

#Sensitivity (True Positive Rate)
rf_sens <- sum(rf_pred_class == 1 & y_test == 1) / sum(y_test == 1)

#Specificity (True Negative Rate)
rf_spec <- sum(rf_pred_class == 0 & y_test == 0) / sum(y_test == 0)

rf_acc
```

```
## [1] 0.7995227
```

```
rf_misc
```

```
## [1] 0.2004773
```

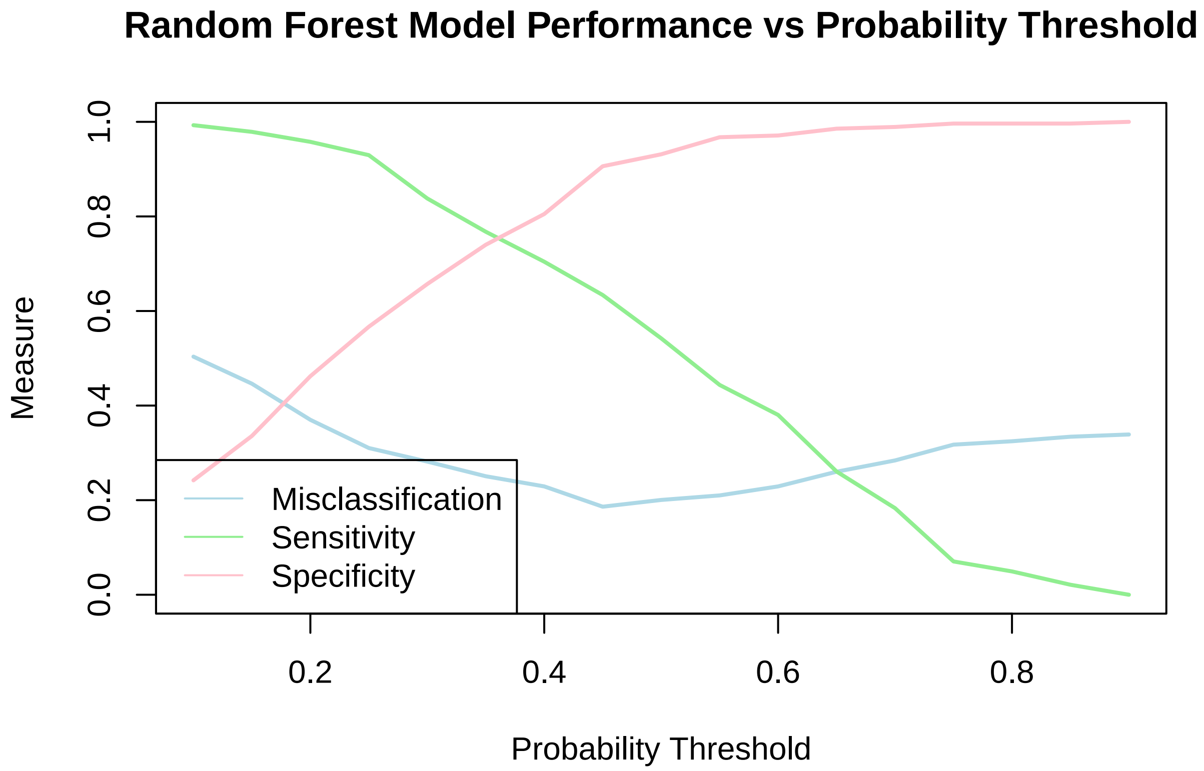
```
rf_sens
```

```
## [1] 0.5422535
```

```
rf_spec
```

```
## [1] 0.9314079
```

```
thresholds  <- seq(0.1,0.9, by = 0.05)

accuracy <- c()
misclassification <- c()
sensitivity <- c()
specificity <- c()

for (t in thresholds) {
  preds <- as.numeric(rf_pred_probs > t)

  acc <- mean(preds == y_test)
  misc <- 1 - acc
  sens <- sum(preds == 1 & y_test == 1) / sum(y_test == 1)
  spec <- sum(preds == 0 & y_test == 0) / sum(y_test == 0)

  accuracy <- c(accuracy, acc)
  misclassification <- c(misclassification, misc)
  sensitivity <- c(sensitivity, sens)
  specificity <- c(specificity, spec)
}

#Base plot
plot(thresholds, misclassification, type="l", col="lightblue", lwd=2, ylim=c(0,1),
     xlab="Probability Threshold", ylab="Measure",
     main="Random Forest Model Performance vs Probability Threshold")
lines(thresholds, sensitivity, col="lightgreen", lwd=2)
lines(thresholds, specificity, col="pink", lwd=2)

legend("bottomleft", legend=c("Misclassification", "Sensitivity", "Specificity"),
       col=c("lightblue", "lightgreen", "pink"), lwd=1)
```



```r
#Finding where misclassification is lowest for Random Forest

rf_best_index <- which.min(misclassification)

rf_best_threshold <- thresholds[rf_best_index]
rf_best_misclassification <- misclassification[rf_best_index]
rf_best_sensitivity <- sensitivity[rf_best_index]
rf_best_specificity <- specificity[rf_best_index]


cat("Best Probability Threshold:", rf_best_threshold, "\n")
```

```
## Best Probability Threshold: 0.45
```

```r
cat("Misclassification at best probability threshold is", rf_best_misclassification, "\n")
```

```
## Misclassification at best probability threshold is 0.1861575
```

```r
cat("Sensitivity at best probability threshold is", rf_best_sensitivity, "\n")
```

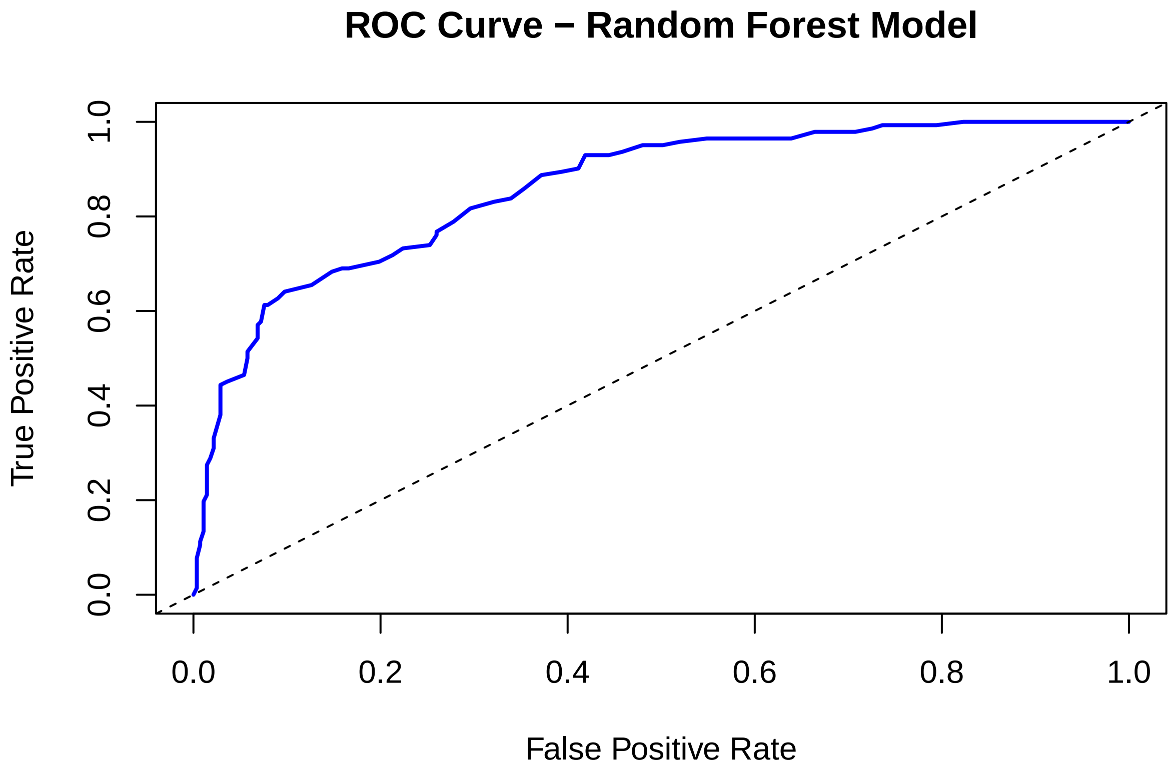
```
## Sensitivity at best probability threshold is 0.6338028
```

```r
cat("Specificity at best probability threshold is", rf_best_specificity, "\n")
```

```
## Specificity at best probability threshold is 0.9061372
```

```r
get_roc_data <- function(y_true, probs) {
  thresholds <- seq(0, 1, by = 0.01)
  tpr <- c()  # Sensitivity
  fpr <- c()  # 1 - Specificity

  for (t in thresholds) {
    pred_class <- as.numeric(probs >= t)

    tp <- sum(pred_class == 1 & y_true == 1)
    fn <- sum(pred_class == 0 & y_true == 1)
    fp <- sum(pred_class == 1 & y_true == 0)
    tn <- sum(pred_class == 0 & y_true == 0)

    tpr <- c(tpr, tp / (tp + fn))
    fpr <- c(fpr, fp / (fp + tn))
  }

  return(list(fpr = fpr, tpr = tpr))
}
```

```r
rf_roc <- get_roc_data(y_test, rf_pred_probs)

# Plot ROC Curve
plot(rf_roc$fpr, rf_roc$tpr, type = "l", col = "blue", lwd = 2,
     xlab = "False Positive Rate", ylab = "True Positive Rate",
     main = "ROC Curve - Random Forest Model")
abline(0, 1, lty = 2, col = "black")
```



```
get_auc <- function(fpr, tpr) {
  # Order by increasing FPR
  ord <- order(fpr)
  fpr <- fpr[ord]
  tpr <- tpr[ord]

  auc <- sum(diff(fpr) * (tpr[-1] + tpr[-length(tpr)]) / 2)  #Trapezoid method
  return(auc)
}

rf_auc <- get_auc(rf_roc$fpr, rf_roc$tpr)

cat("AUC for Random Forest Model:", round(rf_auc, 4), "\n")
```

```
## AUC for Random Forest Model: 0.859
```

```
library(MASS)
```

```
## Warning: package 'MASS' was built under R version 4.4.3
```

```
#Train LDA model
lda_model <- lda(X_grid[trainFlag, ], grouping = as.factor(y[trainFlag]))

#Predict on test set
```

```
lda_pred <- predict(lda_model, X_grid[!trainFlag, ])
lda_probs <- lda_pred$posterior[,2]

#Using Threshold to get predicted classes
lda_class <- as.numeric(lda_probs > 0.5)
y_test <- y[!trainFlag]

#Evaluate the performance of the model

#Accuracy
lda_acc <- mean(lda_class == y_test)
#Misclassification
lda_misc <- 1 - lda_acc
#Sensitivity
lda_sens <- sum(lda_class == 1 & y_test == 1) / sum(y_test == 1)
#Specificity
lda_spec <- sum(lda_class == 0 & y_test == 0) / sum(y_test == 0)

cat("LDA Misclassification:", lda_misc,"\n")
```

```
## LDA Misclassification: 0.3627685
```

```
cat("LDA Sensitivity:", lda_sens,"\n")
```

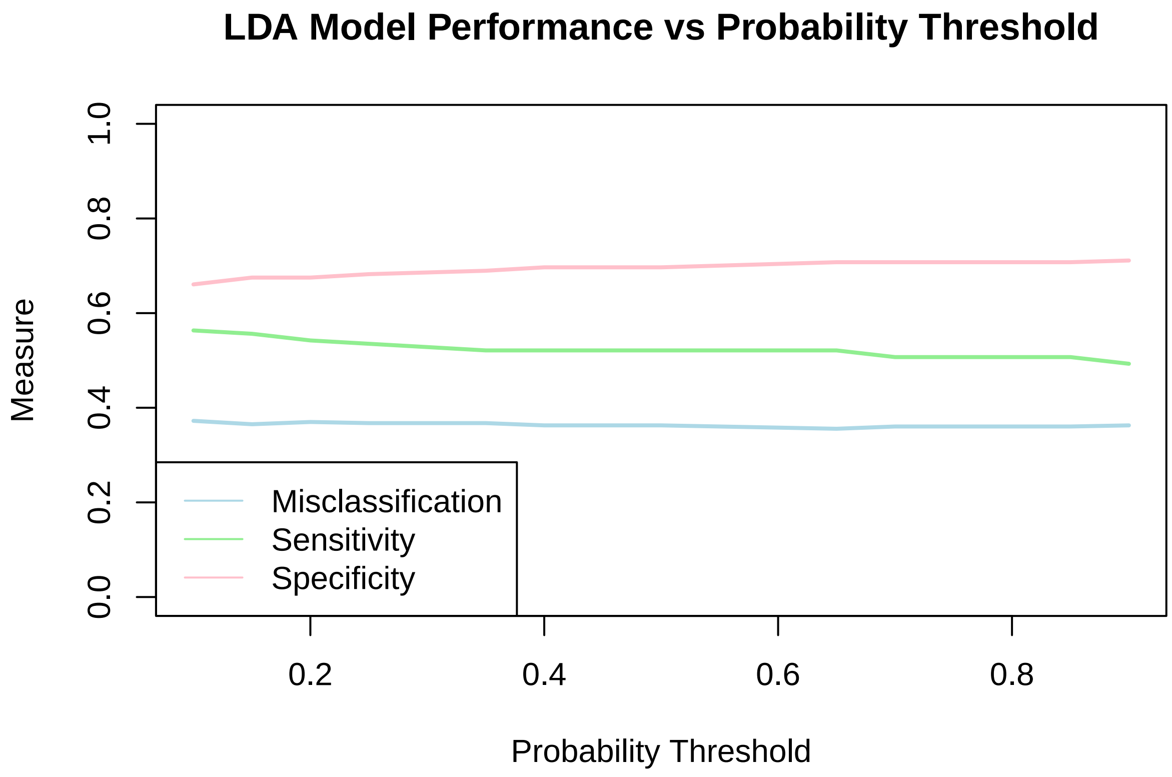
```
## LDA Sensitivity: 0.5211268
```

```
cat("LDA Specificity:", lda_spec,"\n")
```

```
## LDA Specificity: 0.6967509
```

```
thresholds  <- seq(0.1,0.9, by = 0.05)

lda_accuracy <- c()
lda_misclassification <- c()
lda_sensitivity <- c()
lda_specificity <- c()

for (t in thresholds) {
  lda_preds <- as.numeric(lda_probs > t)

  acc <- mean(lda_preds == y_test)
  misc <- 1 - acc
  sens <- sum(lda_preds == 1 & y_test == 1) / sum(y_test == 1)
  spec <- sum(lda_preds == 0 & y_test == 0) / sum(y_test == 0)

  lda_accuracy <- c(lda_accuracy, acc)
  lda_misclassification <- c(lda_misclassification, misc)
  lda_sensitivity <- c(lda_sensitivity, sens)
  lda_specificity <- c(lda_specificity, spec)
}
```

```r
#Base plot
plot(thresholds, lda_misclassification, type="l", col="lightblue", lwd=2, ylim=c(0,1), xlab="Probabilit
     main="LDA Model Performance vs Probability Threshold")
lines(thresholds, lda_sensitivity, col="lightgreen", lwd=2)
lines(thresholds, lda_specificity, col="pink", lwd=2)

legend("bottomleft", legend=c("Misclassification", "Sensitivity", "Specificity"),
       col=c("lightblue", "lightgreen", "pink"), lwd=1)
```



```r
#Finding where misclassification is lowest for LDA

lda_best_index <- which.min(lda_misclassification)

lda_best_threshold <- thresholds[lda_best_index]
lda_best_misclassification <- lda_misclassification[lda_best_index]
lda_best_sensitivity <- lda_sensitivity[lda_best_index]
lda_best_specificity <- lda_specificity[lda_best_index]


cat("Best Probability Threshold:", lda_best_threshold, "\n")
```

```
## Best Probability Threshold: 0.65
```

```
cat("Misclassification at best probability threshold is", lda_best_misclassification, "\n")
```

```
## Misclassification at best probability threshold is 0.3556086
```

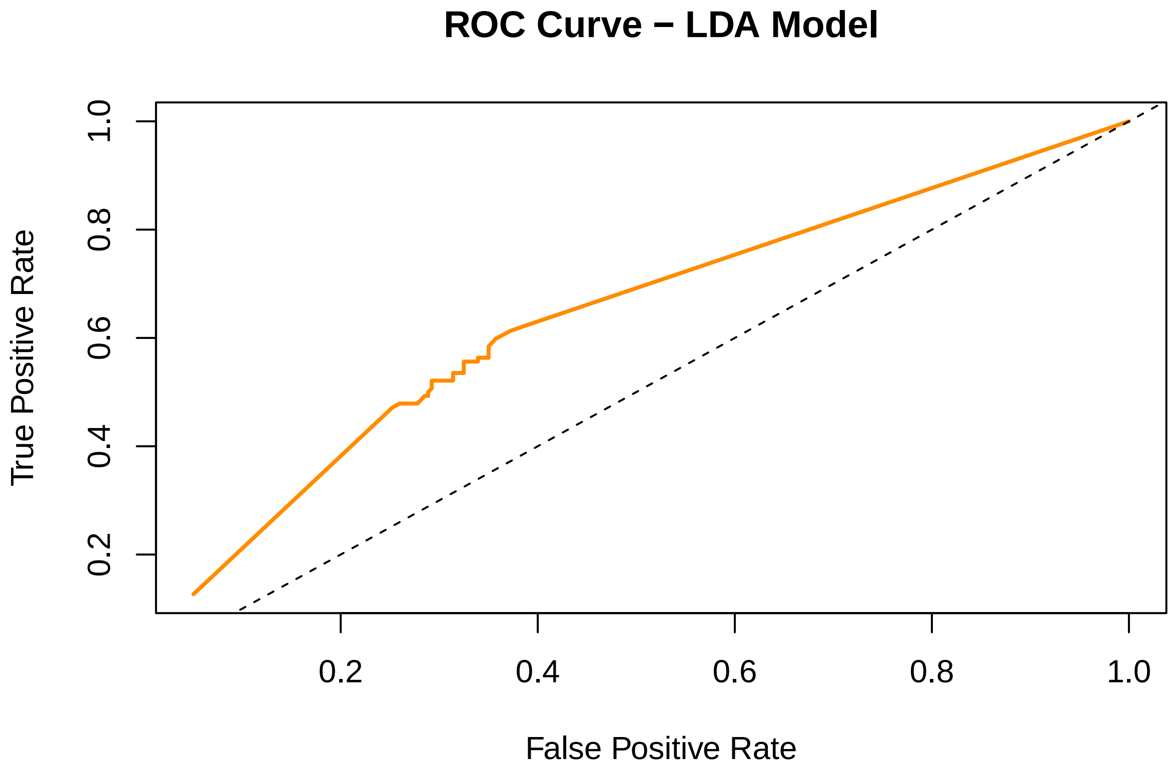
```
cat("Sensitivity at best probability threshold is", lda_best_sensitivity, "\n")
```

```
## Sensitivity at best probability threshold is 0.5211268
```

```
cat("Specificity at best probability threshold is", lda_best_specificity, "\n")
```

```
## Specificity at best probability threshold is 0.7075812
```

```
lda_roc <- get_roc_data(y_test, lda_probs)

# Plot ROC Curve for LDA
plot(lda_roc$fpr, lda_roc$tpr, type = "l", col = "darkorange", lwd = 2,
     xlab = "False Positive Rate", ylab = "True Positive Rate",
     main = "ROC Curve - LDA Model")
abline(0, 1, lty = 2, col = "black")
```



```
#AUC

lda_auc <- get_auc(lda_roc$fpr, lda_roc$tpr)
cat("AUC for LDA Model:", round(lda_auc, 4), "\n")
```

```
## AUC for LDA Model: 0.6305
```

```
##KNN Model

library(class)
```

```
## Warning: package 'class' was built under R version 4.4.3
```

```
#Create test and train data
X_train <- X_grid[trainFlag, ]
X_test <- X_grid[!trainFlag, ]
y_train <- as.factor(y[trainFlag])
y_test <- y[!trainFlag]

#Run K-nearest neighbor, starting with k=5
knn_pred <- knn(train = X_train, test = X_test, cl = y_train, k = 5, prob = TRUE)

#Convert predictions to numeric
knn_class <- as.numeric(as.character(knn_pred))

#Accuracy
knn_acc <- mean(knn_class == y_test)

#Misclassification
knn_misc <- 1 - knn_acc

# Sensitivity
knn_sens <- sum(knn_class == 1 & y_test == 1) / sum(y_test == 1)

# Specificity
knn_spec <- sum(knn_class == 0 & y_test == 0) / sum(y_test == 0)

# Print
cat("KNN (k=5) Misclassification:", knn_misc, "\n")
```

```
## KNN (k=5) Misclassification: 0.2696897
```

```
cat("Sensitivity:", knn_sens, "\n")
```

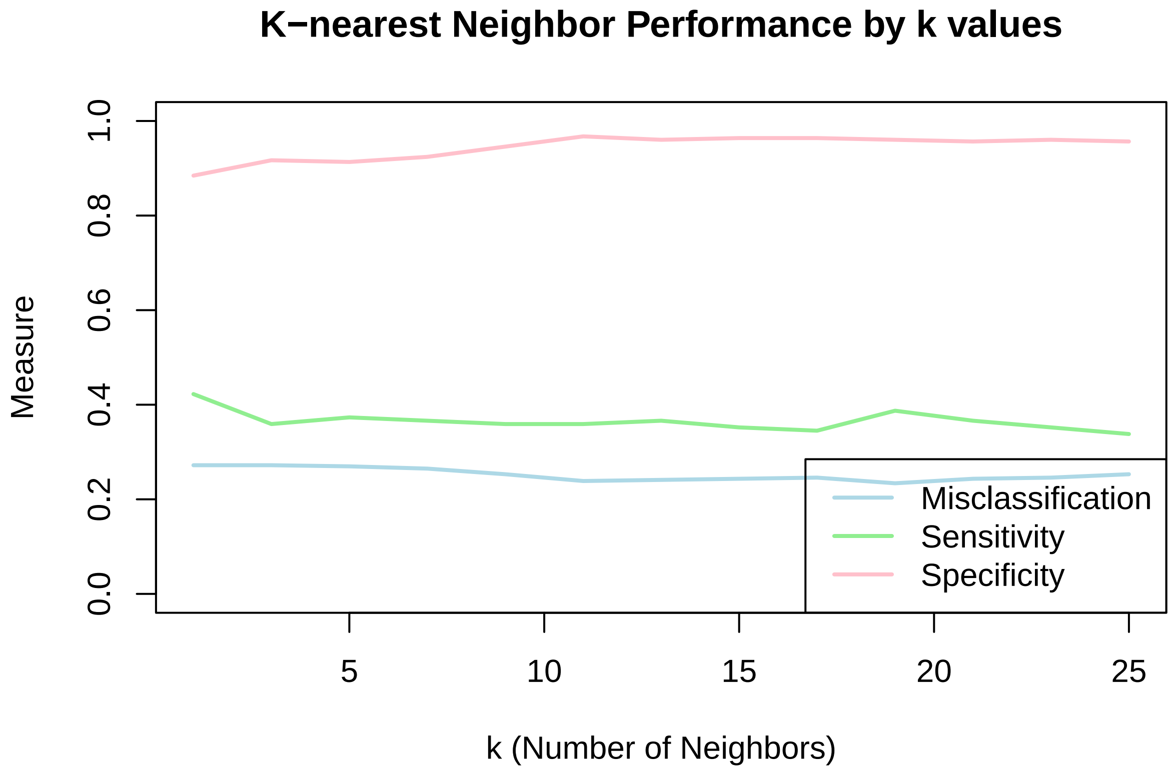
```
## Sensitivity: 0.3732394
```

```
cat("Specificity:", knn_spec, "\n")
```

```
## Specificity: 0.9133574
```

```
k_vals <- seq(1, 25, by=2)
acc_vec <- c()
misc_vec <- c()
sens_vec <- c()
spec_vec <- c()
```

```r
for (k in k_vals) {
  pred <- knn(train = X_train, test = X_test, cl = y_train, k = k)
  pred_num <- as.numeric(as.character(pred))

  acc <- mean(pred_num == y_test)
  misc <- 1 - acc
  sens <- sum(pred_num == 1 & y_test == 1) / sum(y_test == 1)
  spec <- sum(pred_num == 0 & y_test == 0) / sum(y_test == 0)

  acc_vec <- c(acc_vec, acc)
  misc_vec <- c(misc_vec, misc)
  sens_vec <- c(sens_vec, sens)
  spec_vec <- c(spec_vec, spec)
}

# Plot
plot(k_vals, misc_vec, type="l", col="lightblue", ylim=c(0,1), lwd=2,
     xlab="k (Number of Neighbors)", ylab="Measure",
     main="K-nearest Neighbor Performance by k values")
lines(k_vals, sens_vec, col="lightgreen", lwd=2)
lines(k_vals, spec_vec, col="pink", lwd=2)
legend("bottomright", legend=c("Misclassification", "Sensitivity", "Specificity"),
       col=c("lightblue", "lightgreen", "pink"), lwd=2)
```



```
knn_best_index <- which.min(misc_vec)

best_kvalue <- k_vals[knn_best_index]
knn_best_misclassification <- misc_vec[knn_best_index]
knn_best_sensitivity <- sens_vec[knn_best_index]
knn_best_specificity <- spec_vec[knn_best_index]


cat("Best Performing K value:", best_kvalue, "\n")
```

```
## Best Performing K value: 19
```

```
cat("Misclassification at best K value is", knn_best_misclassification, "\n")
```

```
## Misclassification at best K value is 0.2338902
```

```
cat("Sensitivity at best K value is", knn_best_sensitivity, "\n")
```

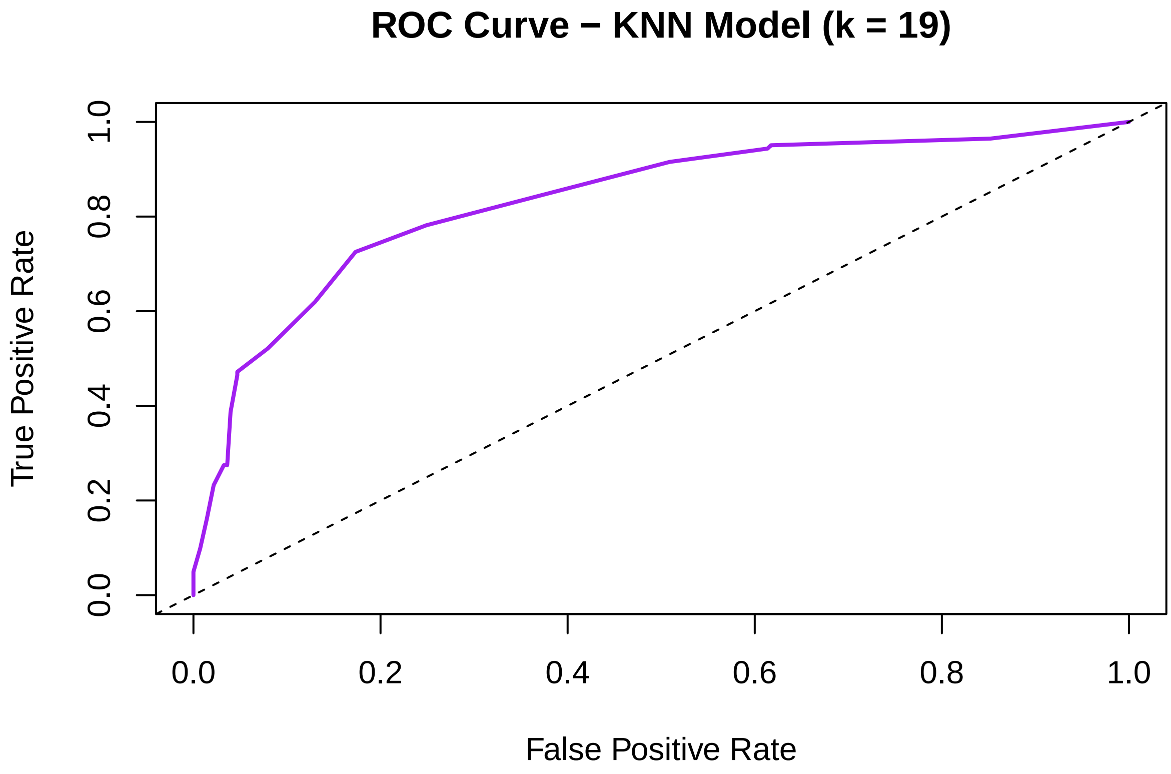
```
## Sensitivity at best K value is 0.3873239
```

```
cat("Specificity at best K value is", knn_best_specificity, "\n")
```

```
## Specificity at best K value is 0.9602888
```

```
knn_pred <- knn(train = X_train, test = X_test, cl = y_train, k = best_kvalue, prob = TRUE)

# Get vote proportions
knn_vote_probs <- attr(knn_pred, "prob")

# Predicted class labels (as numeric)
knn_class <- as.numeric(as.character(knn_pred))

# Convert to class-1 probability (outdoor-day)
# If predicted class is 1, use prob directly; otherwise, use 1 - prob
knn_probs <- ifelse(knn_class == 1, knn_vote_probs, 1 - knn_vote_probs)
```

```
knn_roc <- get_roc_data(y_test, knn_probs)

# Plot ROC
plot(knn_roc$fpr, knn_roc$tpr, type = "l", col = "purple", lwd = 2,
     xlab = "False Positive Rate", ylab = "True Positive Rate",
     main = "ROC Curve - KNN Model (k = 19)")
abline(0, 1, lty = 2, col = "black")
```



```
knn_auc <- get_auc(knn_roc$fpr, knn_roc$tpr)
cat("AUC for KNN Model (k = 19):", round(knn_auc, 4), "\n")
```

```
## AUC for KNN Model (k = 19): 0.8334
```